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FERROINCLAVE: A FIREPROOF BUILDING MATERIAL.

By H. F. COBB.

[Read before the Civil Engineers' Club of Cleveland, December 8, 1903.*]

ON December 17, 1900, as many of you will remember, practically all of the buildings of the Brown Hoisting Machinery Company were destroyed by fire. The only exception was the pattern shop and office building, both of which were easily accessible to the firemen on account of surrounding driveways. The fire started in a gasoline tank, and in seven minutes it had traveled a distance of about 650 feet, through buildings which were considered a very safe risk by the fire insurance people. The walls were of brick, and the floor of 2-inch plank nailed to 4 x 4-inch stringers set in cinders. The roof was of 2-inch plank, covered with slate, and was supported upon steel trusses and columns. Since the roof and floor were practically the only parts of these buildings which could burn and since the distance from the floor to the ridge was about 46 feet, you may readily see why they were considered safe.

In view of the loss entailed by this fire, and of the much greater loss due to the interruption of our business at a time when we were crowded with orders, it is no wonder that Mr. Brown decided upon having the new shops constructed of fireproof material. Our main shop, in which we erect furnace hoists and other machines of great height, required a very complete crane service, with some of the cranes very high up. The ridge had to be about 87 feet from the floor. If the walls were built of brick, they would have to be

*Manuscript received December 17, 1903.—Secretary, Ass'n of Eng. Socs.

made very thick at the bottom, or else they would have to be supported on the structural work. In the first case, the cost of the wall would be high, and in the second case the cost of the structural work would be great. In order to light the shop to the best advantage, the saw-tooth construction was adopted. It was also decided that the floors should be of concrete. Mr. Alexander Brown invented a fireproof window sash, which we have since found to be most satisfactory. Thus we gradually determined what the general plan was to be, and began to look into details.

Among the first of these was the question of the kind of roofing. We wanted a fireproof roof which should be light, cheap and able to withstand the action of steam and sulphurous gases, which would not condense moisture badly and which should be a poor conductor of heat.

The only possibility in the way of a wooden roof would be one with sprinklers underneath. This, including the cost of nozzles, piping, tanks, etc., would have cost us upwards of $30 per "square" of 100 square feet. However, we wanted no wood in this building, so the great cost was not the only thing against this. Ordinary corrugated iron was not suited to the saw-tooth construction, on account of leakage and condensation. Also, it would increase the cost of heating, because it is a good conductor of heat.

Book tile, covered with slate, makes a good roof, but a very expensive one, on account of the great number of subpurlins required, and on account of its great weight, which necessitates heavy columns and trusses. Also, it is not well adapted to the saw-tooth construction.

Reinforced concrete roofs seemed to be the only ones which approached our requirements. Some of these were so made that a large part of the reinforcing metal was exposed on the under side. Of course, these could not last long, because the sulphuric acid and moisture, always in the atmosphere, would soon eat the metal away.

Some of the reinforced concrete roofs were made with the metal entirely imbedded in cinder concrete. Here again the metal would be eaten away. Also, where the concrete is made weak and the metal is not very strong, the thickness of the concrete must be several inches. This makes the roof heavy and thus increases the cost of the structural work.

In general, all of the reinforced concrete roofs, concerning which we could obtain any information, were too heavy and expensive, and required a tremendous amount of centering, which made the erection slow.

In putting up one of these roofs, the first thing is practically to build a wooden roof. Then a thin layer of rich concrete is spread evenly over the boards, and on top of this is placed the reinforcing metal. On top of this is then tamped some 2 or 3 inches of concrete, which is smoothed off and allowed to set for a week or more before the centering or wooden roof is taken down. If the under side is to look well, it must then be smoothed off by a plasterer, who puts on varying thicknesses of cement plaster until the marks of the centering boards are covered up. As the roof now has a large number of cracks in it, and as the concrete itself is not impervious to water, it is necessary to place on top about four plies of tarred felt, covered with pitch or asphalt and slag or gravel.

Mr. Alexander Brown determined that, since we could not buy what we wanted, we would make it. To do away with the centering, he made the reinforcing metal stiff enough to support the weight of the concrete. To make the concrete impervious, he used a richer mixture, one part of Portland cement to two parts of sand. At the same time, the stiffness and quantity of the reinforcing metal and the great strength of the concrete made it possible to obtain all the strength required with a roof only from one-half to one-third as thick and as heavy as any other. Hence, there was a saving in concrete and in structural work.

The two patents, which Mr. Brown took out, covered the shape of the reinforcing material and the method of forming it. This reinforcing material, which we now call "ferroinclave," is a corrugated sheet steel. The depth of the corrugations is ½ inch, and the distance from center to center of each is 2 inches. On both the upper and the under side they are of a dovetail shape, with the

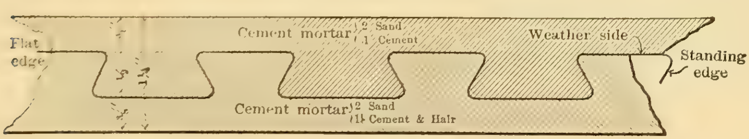


Fig. 1. Section of Complete Roofing.

inner portion about ¼ inch wider than the outer. Fig. 1 is a section of a ferroinclave sheet, which is coated with concrete to the thickness used in the majority of roof constructions. Of course, the sheets had to be so formed that they would fit into each other and form a continuous surface. At the sides of the sheets this was an easy matter, because, if the last corrugations were left uncompleted, with the metal horizontal, they could be lapped and riveted. At the ends, however, a satisfactory joint could not be made without

shingling the sheets, and this made it necessary that the corrugations at one end of the sheet be wider than those at the other. You may readily see that the design of dies to form the ferroinclave was a difficult matter.

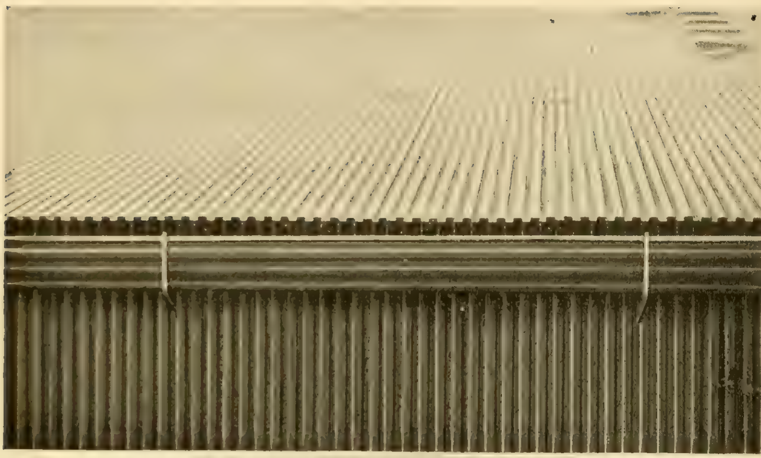
I will not describe the details of the machine, because you who are here to-night are interested more in results. Briefly, I would say that the ferroinclave is formed in two operations. The first one forms corrugations shaped like a wall tent. The second crushes down the ridge of this tent until its roof is flat.

The standard sheets, so formed, are 20 inches wide by 10 feet long, and of No. 24 gauge. We have crimped some sheets of No. 22 gauge, but not without springing the dies. Of course, lighter gauges can be formed, but, as there is no demand for them, we will not carry any in stock.

Besides the crimping machine, we have devices for sawing the sheets into shapes to fit gables, cornices, partitions, etc.; also a bending machine, operated by compressed air. This bends the standard sheets lengthwise into a trough shape for the construction of gutters (see Fig. 2), stair-treads, flashings, etc. Another device bends the sheets crosswise for the construction of ridges, valleys, flashings, gutters, etc.

In constructing a roof of this material, the ferroinclave is placed upon the purlins in much the same way that ordinary corrugated iron is laid. The only differences are that, with ferroinclave, a 3-inch lap at the top and bottom of the sheet is sufficient; also the ferroinclave does not rest directly upon the purlin, but bears upon a $\frac{3}{8}$ x $\frac{3}{8}$-inch wrought iron or hardwood strip, of which you will see the value later. Fig. 3 shows an I-beam purlin with a $\frac{3}{8}$ x $\frac{3}{8}$-inch strip on top supporting the ferroinclave. The clips, used for fastening the ferroinclave to the purlins (see Fig. 4), are riveted to the upper part of the corrugation, and securely grip the purlin. One of the two rivets in each clip fastens it to the upper sheet, and the other rivet takes hold of the lower sheet, because we are careful to have all end laps come directly over the purlin. Thus, the clips serve the second purpose of fastening the sheets together endwise. At the side the sheets are lapped about $\frac{3}{4}$ inch, and riveted about every 18 inches. Where there are no great irregularities in the roof, it is watertight as soon as the ferroinclave is laid.

The next operation, in the construction of the roof, is the concreting of the upper side. The mixture which we use is two parts of sand to one part of Portland cement. This is mixed on the ground and hoisted in pails to the roof. It is then spread evenly to a thickness of $\frac{3}{8}$ inch or more above the tops of the corrugations.



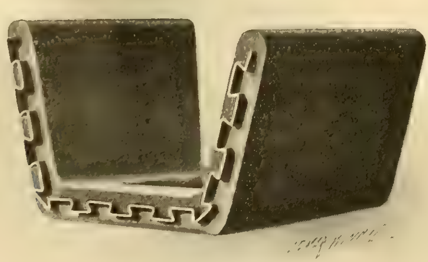


FIG. 2.

GUTTER IN PLACE, BEFORE CONCRETING,
AND
SECTION OF GUTTER, CONCRETED.

The ferroinclave is so stiff that the men may walk over it at will while they are doing this work.

On rainy days, and after the upper side is concreted, the

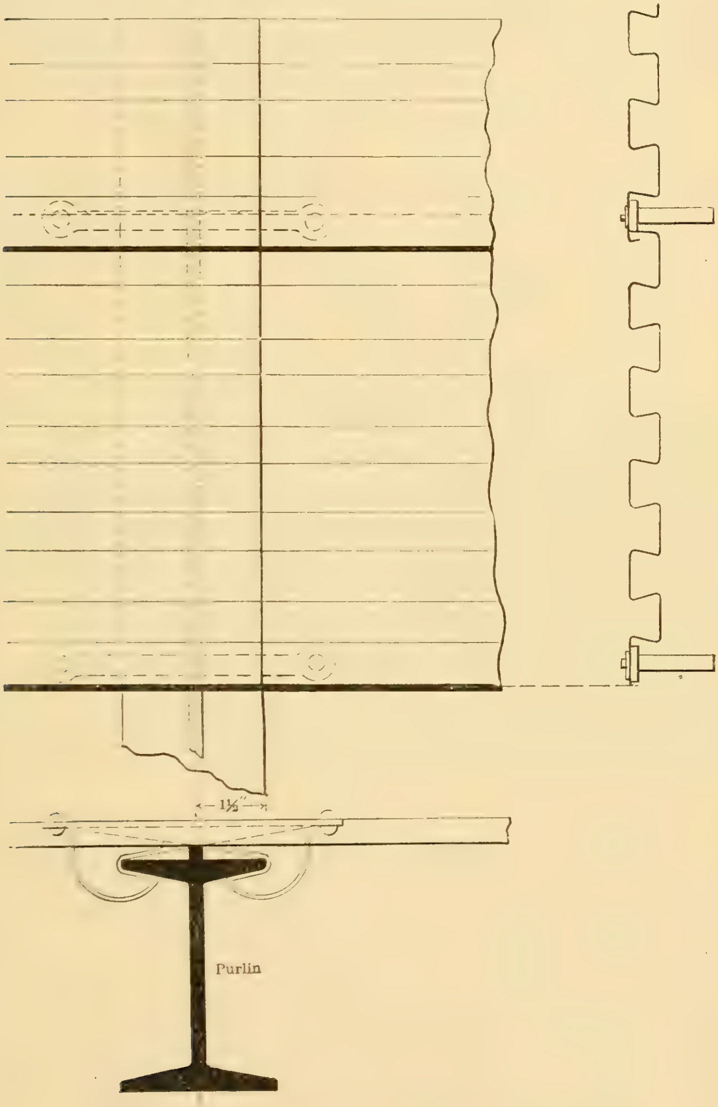


FIG. 3. SECTION THROUGH PURLIN AND FERROINCLAVE.

plasterers coat the under side with the same mixture of cement and sand, to which they add a small amount of hair. This is mixed very stiff and is put on in two operations. The first, or rough coat, just fills the corrugations. The second, or finishing coat, is $\frac{3}{8}$ inch

thick, and is finished usually with a floated or granular surface, which is afterward given a coat of cold-water paint, usually white.

Very often a few cracks may be formed in the concrete on the upper side, and the next operation is to grout these with a mixture of about one part of Portland cement to ten parts of water, put on with a paint brush. Thus, the roof is made a continuous concrete slab, $1\frac{1}{4}$ inches thick, and weighing fifteen pounds per square feet.

The roof is now watertight. The next question which arises is, will the roof be watertight when cold weather comes on? Will not the contraction of the roof cause large cracks to form, through which the rain will pass? The coefficient of expansion of steel is 0.0000065. The coefficient of expansion of the mixture of concrete which we use is 0.0000057. When the temperature outside the building changes the temperature of the roof changes, only not quite so much. Also, the temperature of the purlins changes, but to a less extent than that of the roof. Now, if the change in temperature of the purlins is about $\frac{57}{65}$ as much as the change in temperature of the roof, they will expand and contract together, and there will be no cracks. Also, if, by grouting the cracks at the right time, the roof can be kept in compression, a sudden heating of the purlins, or a sudden cooling of the roof, would only reduce the compressive force and perhaps put it slightly in tension.

Upon some roofs the conditions are very severe, and, as it is impossible to say that any roof will not have any especially rough treatment, that workmen will not make lifts by hanging tackle blocks to the purloins and thus cause them to sag, that a steam pipe will not burst and heat a short section of purlin or a small patch of roof and as many other things cannot be foreseen, we put upon the top of the concrete two heavy coats of our non-drying, waterproofing compound, so that such cracks as might afterward be formed will not permit rainwater to pass through. This compound is a heavy asphaltum paint, so prepared that it will not dry hard, like other paints, for several years.

One of the first buildings for which we furnished a roof was a difficult proposition, because the variation in temperature inside was about 400° F. This caused the purlins to expand and contract violently, and, as these changes in temperature were not communicated to the roof so rapidly or to such an extent, cracks were formed at intervals of about 15 feet. These opened and closed slightly. The method of construction adopted in this case was to grout the cracks, and, instead of waterproofing compound, to use a four-ply tarred felt roofing, stuck on to the concrete.

FIG. 4. CLIPS.

I have thus far confined my description to ferroinclave roofing, because what I have said about this will apply largely to other constructions. The construction of walls is the same, with the exception that, for the sake of appearance, they should be painted with cement wash upon the outer side. The ferroinclave may be fastened to the studs or girts, with the corrugations running either vertically or horizontally, preferably the latter.

Fig. 5 is a section through a window lintel and a ferroinclave wall, showing a good method of making their junction neat and

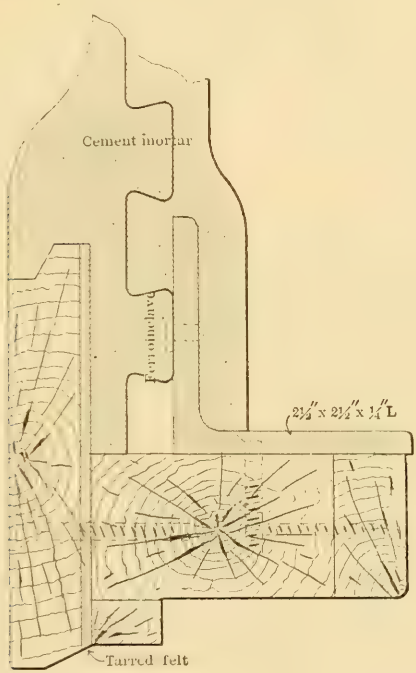


FIG. 5. SECTION THROUGH WINDOW LINTEL.

watertight. Equally good and perhaps better connections can be made around metallic window frames.

The spacing of the studs, like that of the purlins, may be any distance up to 9 feet 9 inches, although we consider 4 feet $10\frac{1}{2}$ inches the best and cheapest.

Floors may be constructed in the same way as the roof, except that the thickness of concrete upon the upper side of the ferroinclave is increased to give the requisite strength. For instance, if the floor is to safely sustain a uniformly distributed load of 150 pounds per square foot on a span of 4 feet $10\frac{1}{2}$ inches, center to center of floor beams, it will be necessary to put $1\frac{1}{2}$ inches of con-

crete upon the upper side, making a total thickness of $2\frac{3}{8}$ inches. For a completely fireproof floor we cover the floor beams with wire netting and plaster cement mortar upon it. Colored tiles may be imbedded in the concrete, to form a wearing surface, or wooden nailing strips may be set in, so that a wooden floor may be put on top. Of course, the concrete itself makes a first-class wearing surface, and is quite good enough for factory use.

Stairways may be made by using channels or reinforced concrete beams at the sides and ferroinclave for treads and risers between.

A section through such a tread and riser is shown in Fig. 6. These treads may be concreted in a great many shapes and may be covered with tile, so as to present a very beautiful appearance. Figs. 7 and 8 show the ferroinclave stair-treads and partitions in our pattern shop.

You will note that fireproof partitions are made in the same manner as ferroinclave walls. The structural supports may be wrapped with netting and cemented. Fireproof doors may be made by placing the ferroinclave in an iron frame.

Reinforced concrete piles may be made by joining end to end a number of ferroinclave sheets, bending them into a pipe shape and concreting them inside and outside, so as to form a solid cylinder, as shown by Fig. 13. These piles are of great value, because of their indestructibility. They will have a great field of usefulness in tropical countries, where the teredo quickly eats out wooden piles, and steel piles are so soon rusted away. In other parts of the world wood is daily becoming more expensive, and as it lasts but a very short time in most cases, it is cheaper and safer to use concrete piles when preparing foundations for valuable and permanent structures.

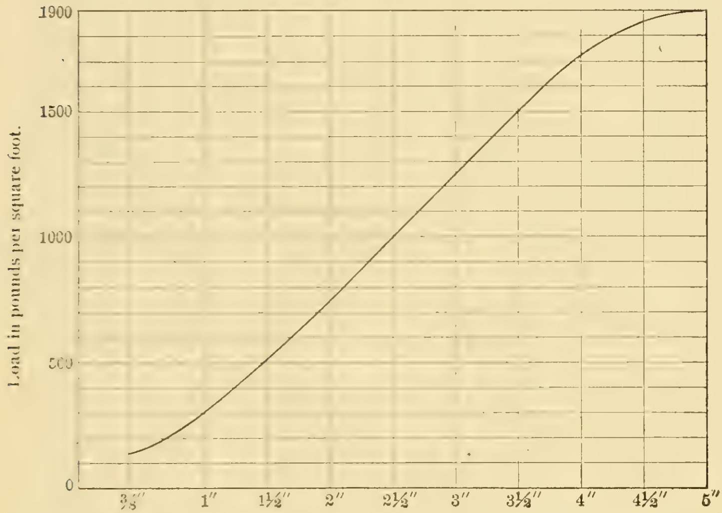
As we have not had an opportunity of collecting much data concerning these piles, I will not go into the matter further. During the coming spring we will make some very extensive tests.

The strength of ferroinclave constructions may be figured in much the same manner as other reinforced concrete constructions, except when the thickness of concrete upon the top of the ferroinclave is small. Then the stiffness of the ferroinclave gives material assistance, and part of the metal is in tension and part in compression. Hence, the only reliable way is to depend upon tests.

Figs. 9 and 10 show the results of a series of tests made upon No. 24 ferroinclave sheets, 20 inches wide by 10 feet long, placed upon two spans of 4 feet $10\frac{1}{2}$ inches each, and coated on the top with the various thicknesses of concrete, which are given as

FIGS. 6, 7 AND 8. STAIRS.

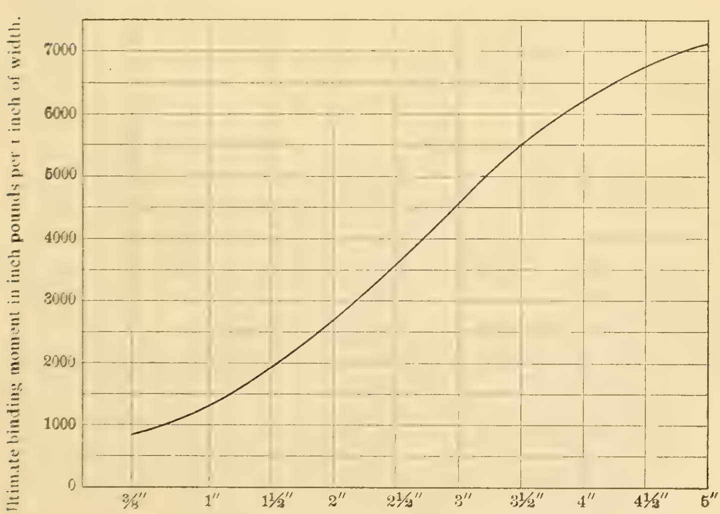
Curve of uniformly distributed loads per square foot, producing ½-inch deflection on a 4-foot 10½-inch span of No. 24 Ferroinclave, painted; then coated with cement, mortar and plaster. Time of setting, 14 days. Width of test pieces, 20 inches. Two spans.



Thicknesses of cement above Ferroinclave, 2 sand to 1 Vulcanite cement; ⅜-inch wall plaster (gypsum) below Ferroinclave.

FIG. 9. LOAD DIAGRAM.

Ultimate bending moments per 1 inch of width of No. 24 Ferroinclave, painted; then coated with cement, mortar and plaster. Two spans, each 4 feet 10½ inches. Tests made upon sheets 20 inches wide. Time of setting, 14 days.



Thicknesses of cement above Ferroinclave, 2 sand to 1 Vulcanite cement; ⅜-inch wall plaster (gypsum) below Ferroinclave.

FIG. 10. MOMENT DIAGRAM.

the ordinates of these curves. Figuring from these tests, we see that, when a ferroinclave roof is made $1\frac{1}{4}$ inches thick and placed upon a span of 4 feet $10\frac{1}{2}$ inches, it will support a uniformly distributed load of 50 lbs. per sq. ft. with a factor of safety of six.

Fig. 11 shows a simple fire test upon ferroinclave roofing. It is loaded to about fifty pounds per square foot and placed upon two spans of 4 feet $10\frac{1}{2}$ inches each. Fig. 12 shows the test pieces after the fire had burned for thirty minutes. Fire and water were alternately concentrated upon these sheets for about an hour, without doing any injury except to sag them very slightly.

Prof. Chas. L. Norton, of the Massachusetts Institute of Technology, who is in charge of the Insurance Engineering Experiment Station, states, concerning tests which he conducted, "The condition of the roof was such that it was still, at the close of the test, a good fire stop, and with a little more cement plastering it would have been in appearance and efficiency in its original condition."

A ferroinclave roof, when made only $1\frac{1}{4}$ inches thick, will conduct heat about $\frac{1}{20}$ as fast as corrugated iron and about six times as fast as 2-inch plank. No trouble has been caused by condensation of moisture upon the under sides in building which were properly ventilated. In buildings where there is liable to be a large amount of moisture, it is better to space the purlins a considerable distance apart, even up to 8 or 9 feet, and to make the roof a little thicker.

The cost of a ferroinclave roof, complete, varies from $20 per square of 100 square feet up to $26 per square when made $1\frac{1}{4}$ inches thick. It may be erected cheaply where plasterers are paid $3.75 per day and where conditions are favorable, and it will cost the maximum figure mentioned above when plasterers receive $7.50 per day of eight hours, as in one city which I might mention.

The average ferroinclave floor costs little more than the roof.

Ferroinclave walls cost from $22 up to $35 per square, depending upon locality, height, etc. Compare this with the cost of brick walls for our main shop, and you will see what a tremendous saving we made.

We sell the ferroinclave in sheets 20 inches wide by 10 feet long, or shorter. The price for the short sheets, and for those oddly cut or bent, is somewhat higher than for the standard 10-feet sheets.

Customers usually send us drawings of their buildings, and we give them prices for all of the ferroinclave and fastening clips required; or, if the buildings are large, we give them prices upon the roof, floor, walls, etc., complete and guaranteed.

FIG. 11. FIRE TEST, BEFORE LIGHTING.

FIG. 12. FIRE TEST, ONE HOUR AFTER LIGHTING.

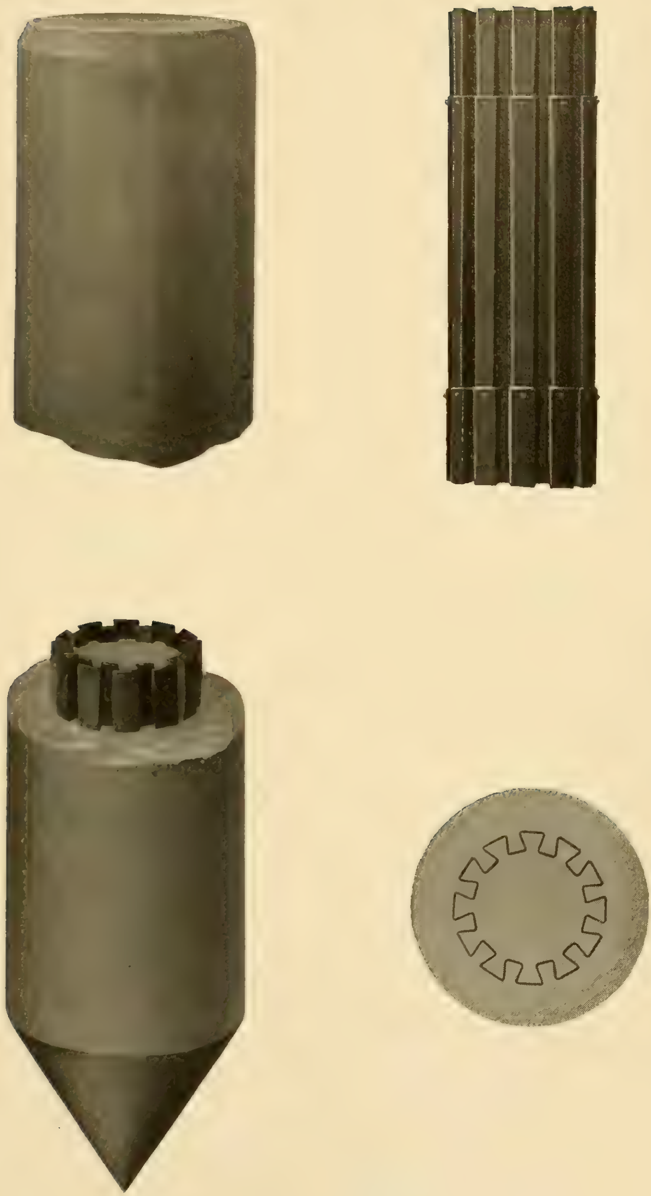


FIG. 13. FERROINCLAVE PILE.

PROPOSED IMPROVEMENTS IN ST. LOUIS TERMINALS.

By A. P. Greensfelder.

[Read before the Engineers' Club of St. Louis, October 7, 1903.*]

Prosperous times seem to come periodically in this American land, and with each period are associated some great forward strides in the development of its resources and in the improvement of the facilities for presenting these products for the benefit of its people. In the period just at hand out of all the numerous advances made in the arts and sciences none stand out more prominently than the progress shown in railroad construction and enlargement. The last few years have witnessed the spreading out of the numerous great trunk lines with wonderful rapidity throughout the United States, reaching out in all directions in order to keep up with the development of new territory or the tremendous increase in volume of business. This business, routed along the rails of all roads in the country, travels to the great business centers for further consignment or for commercial uses. Thus are brought to the large cities great numbers of cars, loaded or unloaded, through-billed or for transfer, for local industrials or for consumption.

Such a town is St. Louis, with a population fourth largest in the United States, the center of twenty-two different railroads, and she presents quite an example of what railroad concentration can imply. Each town in the Union has its problem of the hand ling of the varied railroad freight and passenger business for solution, and this city on the banks of the Mississippi is not an exception. Chicago, Pittsburg, Philadelphia and Boston have each been compelled recently to consider the enlargement and betterment of their railroad terminals; and St. Louis, just reaching that point where business warrants and compels it, has not been slow in expanding and improving to meet existing and future conditions.

Here, in St. Louis, all passenger business is handled from one union station, and a great quantity of local freight and of freight interchange is transferred from one railroad to another, through the medium and under the direction of what is known as the Terminal Railroad Association, or T. R. R. A., of St. Louis.

The T. R. R. A. of St. Louis is an association of fourteen of the twenty-two railroads entering St. Louis or East St. Louis, and was formed by them for the economical and rapid handling

*Manuscript received November 23, 1903.—Secretary, Ass'n of Eng. Socs.

of passenger and freight business through the city. Up to about a year or so ago, its proprietary lines were six in number, and included the Missouri Pacific, the Iron Mountain, the Wabash, the Big Four, the Baltimore and Ohio and the Louisville and Nashville. With the recent addition of the 'Frisco, the Vandalia and the Rock Island, and then the Chicago and Alton, the Southern, the Illinois Central, the Burlington and the Missouri, Kansas and Texas, as proprietary lines, together with the tremendous increase in business within the last few years which it has been compelled to handle, the T. R. R. A. has been made a center of railroad interests of large proportions. In this way, due to ever-increasing business in both freight and passenger channels, the Terminal Association has been compelled to make large additions to, and important improvements in, its facilities. These improvements are partly under way of construction at this time, others have recently been completed and still others are contemplated, but work on them has as yet not been started. It is of these improvements that I will speak in a general way to-night. I will endeavor not merely to recite facts and figures in an offhand way, which might mean nothing except to a railroad man personally acquainted with the present situations, but will try to show the reason for the changes and improvements, and to what extent these alterations will prove beneficial—not only the what, but the reason why and the way how we expect to remedy existing conditions.

For the convenience of the operating department the Terminal properties are divided into four districts, namely, the East St. Louis, the Madison, the Bremen Avenue and the St. Louis Districts. (See Fig. 1.)

The East St. Louis District extends from the stockyards in East St. Louis to East Carondelet, and exercises jurisdiction over the east approach of the Eads Bridge, the tracks in vicinity of relay depot, the freight ranging yards just north of Cahokia Creek and the Conlogue branch to the East Carondelet Ferry. One of the largest improvements in this district is the enlargement of the ranging yard, in which all carload freight received in East St. Louis is separated and classified according to the various roads. The old yard had a capacity of about 1500 40-foot cars, but, with the addition of the new westbound departure yard of 485 cars capacity, and the extension of the eastbound receiving yard to hold 230 cars additional, the capacity of this yard will be increased about 50 per cent. to a total of 2250 cars. The increase in capacity of this yard is essential in order to insure reasonably prompt movement of the extra 1000 cars which are moved in the fall and winter

over and above the daily average of about 3000 freight cars in the St. Louis and East St. Louis Districts. The westbound yard, as built, is somewhat of a novelty in this vicinity, it being what is known as a gravity-switching or "hump" yard. The yard, since it was opened last January, operates very satisfactorily and breaks up a train very rapidly, although its efficiency is somewhat impaired by the fact that there are only 16 tracks in the yard, holding 25 to 35 cars each. The hump is 8 feet above the south end of the yard, and has a 2.4 per cent. grade up and a 3.4 per cent. grade down for 100 feet, when it spreads out to a 0.42 per cent. through the switches on the lead for 1000 feet and then level for 600 feet down the yard. A very large scheme of a cluster yard was worked out for this point, comprising a series of classification yards, in which were arranged a 40-track westbound and southbound classification and departure yard, holding 2000 cars; a 20-track eastbound receiving yard, holding 1100 cars; an eastbound classification yard of 24 tracks, holding 600 cars; an eastbound departure yard of 30 tracks, with a capacity of 1600 cars, and a westbound departure yard of 40 tracks, holding 1000 cars, making a grand total of 6300 cars; but, due to the radical changes necessary in the relocation of the tracks of numerous lines, this scheme was found impracticable.

Relay depot, situated between the head ends of several freight yards, in a triangle of bad railroad crossings, where passenger business to and from Eads Bridge is heavy, and where engine relays are made, is a point which early called for some kind of an interlocking plant to govern train movements. In 1883 the first large interlocking plant of the kind in the country was installed here, and used hydraulic transmission of power. This plant was somewhat altered in 1888, and remodeled into a 71-lever hydro-pneumatic plant. Having run its life since then, it was decided last year to install the latest type of an electric system, and the Taylor Signal Company will be ready within a few weeks to turn over for operation a plant controlled through a 144-lever machine, 104 levers of which are working levers. The plant is modern in every respect, with clay wire conduits, dwarf and high signals, electrically lighted, reserve storage batteries, duplicate power plants and convenient signal bridges.

The Madison District geographically presents itself next for consideration, including, as it does, the territory from Granite City, on the north, down along the east approach of the Merchants Bridge, through Madison and Madison Yards to the Illinois Transfer Railroad and the East St. Louis Belt Line, to the stockyards

in the south. At Granite City, where connection is made for the Merchants Bridge with the Wabash, the Big Four, the Chicago and Alton and the Chicago, Peoria and St. Louis, it will be necessary to remodel the present interlocking plant in order to insure safety to the high-speed runs, which are made at 60 miles an hour through this point by the limited through passenger trains. It is contemplated to substitute for the present mechanical machine of 68 levers, which was installed by the Johnson Signal Company in 1894, with its old mechanical switch-lock movements and out-of-date signal devices, a plant, either power-operated or mechanical, fully equipped with facing point and position locks and all modern improvements.

At Madison Junction, where freight trains to and from Madison Yard leave or enter the tracks leading to Merchants Bridge, without protection to the passenger trains of the northern roads using this bridge, it was deemed necessary to remedy this dangerous condition by the installation of an interlocking plant at this point. Accordingly, a Taylor electric machine of 55 levers is being installed, with proper derails, home and distant signals, signal bridges, etc.

At the Madison Freight Yard, wherein is received and classified freight for numerous lines, as well as all freight routed via Merchants Bridge, in order to reduce the engine mileage to its normal condition, it is necessary to increase the number of tracks. For example, during 1902 the engine days worked increased 65 per cent. over the same period in 1901, while there was only 31 per cent. increase in the number of cars handled. The present plans contemplate, therefore, the enlargement of a yard of 17 tracks, with a total capacity of 600 cars, to a yard with a greater number of tracks and increased car capacity.

On the Illinois Transfer Railroad, which is the outer belt on the east side of the river, connecting with the Illinois Central on the south and with all intersecting lines to the Clover Leaf on the north, and with Madison Yard, there is being laid a long piece of double track to accommodate the rapidly increasing traffic which is properly being handled along this belt.

At a point on the East St. Louis Belt Railroad, where it crosses the Venice and Carondelet Railroad, is a triangular tract of ground of about 20 acres. On this space there are now being built an engine house and repair shops of large capacity, in order to afford proper facilities for the maintenance and repair of the locomotives and car equipment of the company. With the new equipment, which it is intended to purchase, there will be about 100 locomotives to

be provided for, and a large repair yard is necessary. The only shops now maintained are some old buildings at Sixteenth Street, in St. Louis, which it will be necessary to dismantle in order to provide space for other improvements, while the present facilities for car repairs consist merely of small outbuildings scattered through the various yards. It is the intention, therefore, to transfer all repair work of this kind to these new shops, which are very complete and extensive and involve the expenditure of about half a million dollars. The layout includes a roundhouse, machine shop, blacksmith shop, wood and paint shop, storehouse, oil house and power house, and it is intended to provide, at some future time, not only repair tracks of all kinds, but a modern engine-coaling station as well. (See Fig. 2.)

The 80-foot engine roundhouse, of 16 stalls, is modernly equipped with cleaning and wheel pits, is hot-air heated and electrically lighted and is reached through a 70-foot turntable.

The arrangement of shops is such that, by means of the 70-foot transfer table, 304 feet long, of 150 tons capacity, operated by electricity along their entire length between the adjoining machine and blacksmith shops and the wood and paint shops, an engine or car can be brought from the engine house or through the repair yard and run directly to the place desired. The shops are composition-roofed, brick buildings and are designed to fit each its special purpose. The machine shop, 253 feet by 123 feet, is equipped with an 80-ton crane, to enable the shifting of a locomotive bodily, and is well arranged, with its large tools on the ground floor and its lighter tools economically placed on a balcony above. The 75-foot by 123-foot blacksmith shop is equipped with two turntables, serving the forges and machines. The wood and paint shop is 110 feet long by 100 feet wide, and is to handle all wood work for both engines and cars. The two-story storeroom and office building, 128 feet by 53 feet, is located alongside of convenient tracks, and is easily accessible to the material yard and shops.

The 100-foot by 98-foot power house is built sufficiently large to permit installation of more machinery than the present 1000 horse power required to heat, light and furnish power to the various buildings of the group. The equipment is machinery transferred from the present power house at Union Station, St. Louis, and consists of four 250-horse-power Babcock-Wilcox water-tube boilers, three 200-horse-power Erie vertical marine engines, one 350-horse-power Ingersol-Sergeant air compressor of 2150 cubic feet per minute capacity, pumps, etc., and a new 10-ton 42-foot hand-operated crane.

Before turning our attention from the east to the west side of the Mississippi River it may be of interest to mention some work being done on the two connecting links between the Missouri and Illinois Shores.

On the east approach of the Eads Bridge there is now being reconstructed a portion of the railway viaduct between bent 30 and the east abutment, including the long continuous 322-foot $3\frac{7}{8}$-inch girders originally built, and of which style of construction, I believe, there are not many examples in the country. This reconstruction is necessary because that part of the structure will not be strong enough for those new switching engines which the company has ordered, as well as for new road engines of ever-increasing weight. On the main spans of the Eads Bridge, consisting of the center span of 520 feet and two side spans of 502 feet each, a very thorough inspection was made last year, and the bridge was found in remarkably good condition after its thirty years of incessantly heavy service since July 4, 1874. A number of very interesting points were brought out in this inspection, but one in particular showed how well planned and how carefully executed was every detail of manufacture of the material and its erection in this bridge. In order to investigate the strength of the ribs on the main arches it was decided to drill holes through the envelope and staves which go to make up these hollow ribs, which are about 18 inches in diameter. These staves, varying in thickness from $1\frac{1}{8}$ inches to $1\frac{1}{2}$ inches, are made of the toughest 100,000-pound chrome steel, and it was only with the greatest difficulty that we succeeded in piercing them. Nearly a dozen holes were drilled in various spots on the bridge, and in every case we found the inside of the tube in almost as perfect condition as on the day when it was put in place. By means of a unique contrivance of mirrors and electric lights we were enabled to look down inside of the hole, and the original paint coating was found intact. It may be necessary, however, where the outer 5-16-inch envelope has been badly eaten away, to cover the ribs with a new $\frac{3}{8}$-inch envelope, jacketed over the present one, with a filling between of new asphalt.

Some renewals are also being made in the floor beams on the upper roadway, which, being freely exposed to the sulphur, smoke and steam of the engines running beneath them, have been somewhat weakened by corrosion. In addition some gusset plates are being added to the verticals supporting the upper roadway, but, with the exception of the placing of some rigid bracing between these posts, nothing radical is being done whatever on the main

spans. Due to the gases and moisture in the tunnel on the west approach of this bridge, the old steel bridges over Main Street, Second Street and the alley between have badly deteriorated, and are being replaced with entirely new structures.

On the Merchants Bridge, east approach, nothing is being done with the exception of the replacing of the four 67-foot 6-inch girders over Kline Street, which were washed out by the flood in June. An estimate of cost for replacing the one remaining piece of wooden trestlework on this bridge just east of the three 125-foot spans on the east approach was made, and it is not unlikely that this work will be done in the near future.

On the main spans of the Merchants Bridge, in order to secure to the bridge ample strength for the new road engine loading of two 174-ton engines with tenders, involving 50,000 pounds on driver axles, spaced 4 feet 6 inches center to center, as well as for the new terminal switching engine of shifter type, with 68 tons on three driving axles having 11-foot wheel base, and 112 tons total weight of engine and tender, it was found advisable to combine under one track, the four stringers which were previously under the two, and to replace those shifted with two new ones. This work has been completed, and both tracks are now in full service.

On the west approach of Merchants Bridge, the old wooden trestlework, erected when the bridge was built, in 1892, has been replaced with a modern steel viaduct, and a new northwest approach steel viaduct has been built, to make connections with the west belt line. The viaduct is about 35 feet high, with 28-foot towers and 28-foot spans, and is about 820 feet long.

Running off from the Merchants Bridge toward the west, we enter the so-called Bremen Avenue District, which extends from Biddle Street through the Florida Street, Ashley Street, Bremen Avenue and May Street yards toward the northwest belts. What is known as our West Belt Line here extends from its connection at Carrie and Bulwer Avenues westwardly around the city to a connection with the Wabash Railroad near Page Avenue. Good progress has been made on this line recently, and it will shortly be completed, with 5.1 miles of double-track line. The line is located with 8-degree curves and compensated 1 per cent. maximum grades, and is almost entirely free from grade highway or electric railway crossings, which are carried either above or below its tracks. It is the intention to use this belt line for the transfer of through freight destined for points outside of St. Louis, thus contriving to keep out of the crowded Mill Creek Valley this traffic, which unnecessarily tends to congest it. It is possible also that,

during the World's Fair, it may be found desirable to run passenger trains around this belt line, in order to increase the facilities for carrying people to and from the World's Fair Grounds.

There is also being built an outer belt line, known as the St. Louis Belt and Terminal Railway, which runs 16.4 miles, from its connection with the Burlington at Prospect, on the north, around the city to the 'Frisco, at Lindenwood, on the south, connected en route with the Wabash, Rock Island and Missouri Pacific. With its 0.8 per cent. limiting compensated grades, and its 4-degree maximum curves, it is bound to become a busy freight channel for that through business requiring rapid transit, a demand which seems to be yearly increasing, and which develops a tendency to keep such traffic out of the large cities with their consequent terminal delays.

Due to the belt lines and increasing freight tonnage over the Merchants Bridge, the Bremen Avenue District is handling more business every year, so that it is found necessary to enlarge the present Bremen Avenue Freight Yard from its present capacity of 92 cars to hold about 197 cars additional, in order to take care of the necessary distribution at this point. It is also the intention to erect at this point a passenger station of ample capacity.

All passenger trains, from Union Station to the Northern lines and over the Merchants Bridge, are compelled to come down Main Street, which is a public thoroughfare. Due to wagon traffic in this street, and to the great amount of switching in and out of the numerous industrial plants and small yards of the Burlington Railroad and the Terminal Company, this passenger traffic is often blocked. In order, therefore, to reduce these delays to a minimum, a third track has been laid along Main Street, giving a double main-line track from the Union Station, and a system of electric interlocking is being installed between Biddle Street and North Market Street. Due to obstruction of view, three towers are necessary, and a 96-lever machine (70 working) has been placed at North Market Street, a 36-lever machine (24 working) at Mullanphy Street and a 36-lever machine (23 working) at Biddle Street. Due to the location of the tracks in the paved street and the consequent wagon usage, detector bars at switches were found impossible, and track circuits had to be resorted to for indication of train movements. This is somewhat of an experiment in a spot where short circuits are easily caused by muddy streets and by ice and snow in winter, but it is thought that this can be overcome by careful installation.

Following along the Main Street tracks, we enter, at Wash-

ington Avenue, what is known as the St. Louis District, which runs west from this point through Mill Creek Valley and Union Station to Grand Avenue. The changes in this district are most radical, and improvements of a large scope are being inaugurated in order to relieve congestion throughout the valley and to take care of the anticipated extra traffic due to the World's Fair, to be opened on April 30, 1904.

One of the largest improvements suggested, and one which has created a great deal of popular discussion, through the newspapers, at least, is the proposed double track connection between Eads Bridge and the Merchants Elevated tracks, commonly known as the "Loop." This plan contemplated the building of a steel elevated structure, about 2200 feet long, from a connection with the tracks on Eads Bridge just west of the main spans, and curving westward and southward on a down grade until it ran parallel to and on a level with the present elevated Merchants tracks at a point near Market Street. In addition it was proposed to four-track, from Market Street around to Twelfth Street, the present double-track Merchants Elevated, a distance of about 6600 feet, thus affording a four-track channel to and from Union Station. This scheme involved the expenditure of a large sum of money, and was undertaken with the idea of obviating the so-called tunnel nuisance to passengers traveling via Eads Bridge, and to increase the capacity of Eads Bridge with the consequent betterment of service on the main line tracks between relay depot and Union Station.

The avoidance of smoke and gases in the tunnel is impossible because of the extremely heavy traffic at busy intervals of the day, and of its location in the heart of the business part of St. Louis, where ventilating shafts would not be tolerated. The actual operating time limit between the following trains through the tunnel is about four minutes, due to the fact that its cross section prohibits proper curve elevation around a curvature of $11\frac{1}{2}$ degrees. The following, from the train sheet of October 3, 1903, shows the average daily traffic through the tunnel and over the Eads Bridge in twenty-four hours:

Eastbound—	
Passenger trains	53
Freight trains hauling 532 cars	23
Light engines	22
Total	98

Between 7.25 and 9.42 A.M. were run 16 trains.

Between 8.29 and 10.13 P.M. were run 15 trains.

On four-minute, least schedule.

Westbound—

Passenger trains	52
Freight trains hauling 669 cars	29
Light engines	14
Total	95

Between 6.58 and 8.25 A.M. were run 14 trains.
Between 6.12 and 8.27 P.M. were run 16 trains.
On three-minute, least schedule.

The tunnel grades are 80 feet to the mile, and in its construction, sufficient provision not having been made for drainage, perfect track maintenance is difficult.

The smoke, besides being distasteful to the traveling public, is also a serious detriment to train operation, for its density is such as to prevent positive observation of any signals placed in the tunnel, and compels the establishment, for absolute safety, of the positive block, which makes it impossible for the entrance of one train into the tunnel until a preceding train on that track has cleared the exit at the other end. It is thought, therefore, that the building of the "Loop" and of the two additional elevated tracks would, in a large measure, prevent the delays caused by volume of traffic and by the failure of inbound trains to reach East St. Louis on schedule time, and that the separation of freight from passenger traffic at Main Street, and the running of the former only through the "Hole," would enable prompter service to be given in every way.

In the Mill Creek Valley itself the rearrangement of tracks and yards will be so thorough that the present railroad map through this territory will scarcely be recognizable. The present Twelfth Street classification yard will be increased in capacity 10 per cent. from its total of 133 cars, but the Fourteenth Street team yard will be moved and three new engine houses built there, each to be served by electric transfer tables. About 200 car capacity of the present Sixteenth Street freight team yard, including the coal business, will be removed to Compton Avenue, leaving only about 158 car capacity of the yard for team delivery of carload merchandise, enabling us, therefore, to increase our Seventeenth Street coach storage yard from a capacity of 75 cars to hold at least 235 80-foot coaches. The removal of the present engine house and machine shops to East Madison will enable us to place in that locality an engine-coaling yard, to accommodate all eastern and terminal engines using Union Station. The coaling yard will be centered about a 1000-ton capacity coaling station, equipped with all the latest devices for the rapid watering, coaling and sanding

of engines. Cleaning pits will be located beneath the building, enabling the ashes, as well as all coal and sand, to be handled with link-belt machinery.

The area just east of Twenty-first Street, cleared of the team yard, transferred to Compton Avenue, and the old coach storage yard, moved to Atlantic Street, has been covered with a new small coach-storage yard of about 90 cars capacity, intended to hold special and private cars near the station, where they may be quickly reached in making up trains, and also with a 45-car head-end yard, provided with 10-foot roadways between tracks and timber-floored throughout to enable access by both trucks and wagons to such train head-end stuff as baggage, milk, theatrical paraphernalia and carload mail. In the same vicinity, just east of the new express houses to be rebuilt, on the west side of the approach into Union Station, in order to enable the laying of the new track arrangement at that point, is also built an express yard, holding about thirty cars, and so arranged that each of the express houses will have trucking access to two tracks. (See Fig. 3.)

Between Ewing and West Jefferson Avenue is being built a coach-storage yard, large enough to accommodate 245 80-foot cars, with additional repair capacity of 20 cars. This yard will provide for all coaches taken from the present Twenty-first Street District, and some in addition. A small power house, of 250 horse power, is being installed in this yard to furnish steam for car heating. Air for cleaning purposes and for air-brake testing, as well as water for washing cars, is being piped all over, and the yard is to be provided with convenient coal bins, car-repair store-rooms, wheel yards, etc., so that economical care of coaches is insured. (See Fig. 4.)

At Compton Avenue, the present team yard of 232 cars capacity will be enlarged to hold about 630 cars. In this bulking yard will be handled large quantities of coal and carload goods of all kinds, destined for local consumption in the central and western part of the city. The present plans contemplate the building, from Grand Avenue to Union Station, of two main-line tracks, on which to handle all western passenger business and to direct its movements into the station. At the station itself improvements of large conception are being carried out, all of which are designed to increase, in various ways, the present cramped facilities at this Union Station, which, when it was opened for service, September 2, 1894, was thought to be so large that it would require a city growth of at least twenty-five years before it would be overtaxed in any manner.

The St. Louis Union Station handles a kind of business peculiarly its own; for, instead of being a terminal station in the true sense of the word, such as Boston or New York, or an intermediate station, such as Pittsburg or Philadelphia, it is essentially a transfer station. Lines from the East, West, North and South bring in solid trains of cars, which, almost without exception, stop at this point, but each of which brings passengers, mail, baggage and express for interchange and distribution among all others. Another fact explaining the necessity for large train space is that the percentage ratio of suburban and through traffic, as compared with other large cities, is remarkably small. Out of the 135 outbound and 135 inbound daily trains, scheduled on a time-table dated August 30, 1903, not more than 10 per cent. is suburban business. However, it is believed, that if the capacity of the present 32 tracks in the train shed, which now hold trains of from 4 to 10 cars, is increased, by lengthening all the tracks to a uniform capacity to hold 10 or 11 cars, it will be readily possible to take care of all business by providing, at the same time, sufficient outside coach-storage room to obviate the necessity of using the train shed for that purpose, and also, by so arranging the leads into the train shed that accumulative delays due to fog or unusual conditions are reduced to a minimum.

The present track layout shows four tracks in the neck of the lead approaches into the train shed; but, due to the lack of proper connections and to the necessary method of handling business, seldom more than three and usually not more than two simultaneous moves are permissible at this point. With the purposed arrangement, resembling in appearance two huge bottles, it will be possible to make six parallel moves through the necks, and, with the numerous cross-overs and double slips, the number of possible moves will be almost unlimited. (See Fig. 5.) With the head house on Market Street fixing the location on the north, and the Missouri Pacific tracks determining the southern limit, the only possible directions for enlargement of the present track plan were east and west, and compelled the relocation of the express buildings and power house. In addition to the six main leads above mentioned, movements to and from the yards will be possible along the adjacent express, coach-storage and engine leads. This radical track rearrangement necessitated the replacement of the present large 131-lever electro-pneumatic plant now in operation, with an entirely new system of interlocked switches and signals.

Due largely to the manner in which business must be handled, and partly to the arrangement of present tracks, the number of

trains moving into and out of the station, necessary to receive and dispose of a train are very great. Each train movement requires the throwing of several levers on the interlocking machine, and the number of lever movements for one day is very large. For comparison we have the following for May 11, 1902, as taken from a report by the former superintendent of telegraph, Mr. E. A. Chenery:

Description.	St. Louis Union Sta.	Boston North Sta.	Boston South Sta.	Pittsburg Penna. R. R. Sta.
Scheduled trains, in and out..	224	606	775	....
Light engine movements....	736	....	....	....
Switching movements	573	....	....	....
Passenger movements	364	....	....	....
Freight movements	102	....	....	....
Total train movements	1,835	2,637	2,500	5,349
Total lever movements......	24,956	22,220	27,621	39,419
Average train movement per train scheduled	8.19	4.35	3.36	7.37
Average lever movement per train scheduled	111.41	36.66	36.93	....

In explanation of the fact that, while South Boston has nearly four times as many trains as we have, our train movements are nearly as large and our average moves per train are 145 per cent. greater, it is only necessary to study the head-end movements for handling baggage, mail and express. Taking as one example the make-up of an evening western passenger train, we have the following:

1. Switch engine with coaches and sleepers into train shed.
2. Switch engine light out of train shed.
3. Switch engine light into mail track.
4. Switch engine with mail car out of mail track.
5. Switch engine with mail car into train shed.
6. Switch engine light out of train shed.
7. Switch engine light into express track.
8. Switch engine with express car out of express track.
9. Switch engine with express car into train shed.
10. Switch engine light out of train shed.
11. Road engine light into train shed.
12. Train complete out of train shed.

Instead of one tower, as at present, due to the great distance covered on the new plan, and the convenient grouping of switches, and to train movements at certain points, it is thought better to subdivide the machine into three towers, interlocked between themselves, and governed by a chief operator located at the central station. These three towers, combining in one system 215, 47

and 47 levers respectively, will control the largest interlocking plant in the world.

COMPARISON OF INTERLOCKING SYSTEMS.

Description.	St. Louis New Union Sta.	St. Louis Present Union Sta.	Pittsburg Penna. R. R. Sta.	Boston South Sta.
Year installed	1903	1893	1902	1899
Number of towers	3	1	4	3
Total number of levers	309	131	287	165
Total number of working levers	258	101	242	150
Number levers in largest machine	215	131	131	143
Total number of switches operated	107	61	68	57
Total number of double slips (M. P. F.)	65	12	76	39
Total number of signals operated	235	105	167	144

The Union Switch and Signal Company's electro-pneumatic system is being installed, and it is assured, with the scheme for handling trains over the new layout, that both the train and lever movements will be materially reduced. The 99-foot by 146-foot power house, as relocated near Eighteenth Street Bridge, will be fireproof throughout, and will have a capacity of 2750 horse power. The ten pairs of boilers, fed by automatic stokers drawing from coal automatically delivered, are connected to a large stack 200 feet high. The Westinghouse marine and compound engines are directly connected to generators delivering current at high voltage for light and power. The mechanical equipment includes, besides the usual complement of pumps and feed-water heaters, air compressors, etc., three pumps for operating the (39) hydraulic elevators in the proposed baggage and mail buildings and in the subway system to be presently described. For moving machinery in the engine room a 15-ton, 42-foot, hand-power crane has been installed.

New Express buildings are being built for each of the Adams, Pacific, American, Wells Fargo and United States Express Companies. This group comprises a solid block, extending southwardly from Twentieth Street and Clark Avenue, and is to be two-storied, with basement, brick, slow-combustion buildings, furnishing a large percentage of increase in room required to handle the expanding business. A new large baggage building and a mail building have been planned, and are to be erected in the near future directly adjacent to the train shed. The train shed is being extended 180 feet south, in order to protect the longer trains possible under the

shed
to T
ordin

FIG. 1. PLAN OF ST LOUIS AND EAST ST. LOUIS, SHOWING RAILWAY SYSTEM OF THE TERMINAL R R ASSOCIATION OF ST LOUIS FEBRUARY 1897

Scale, 6 inches = 1 mile

ale, 6 inches = 1 mile.

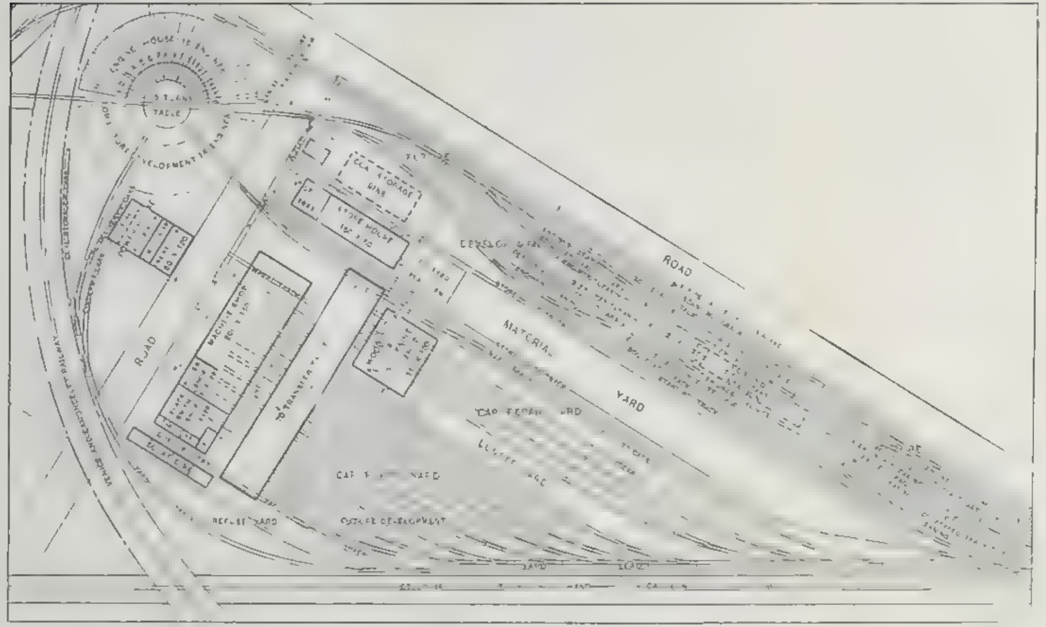


FIG. 2. GENERAL PLAN OF PROPOSED ENGINE YARD AND REPAIR SHOPS AT CROSSING OF THE EAST ST LOUIS BELT AND VENICE AND CARONDELET RAILROADS NORTHWEST OF ST LOUIS NATIONAL STOCK YARDS. OCTOBER 10, 1902

Scale 1 inch = 225 feet

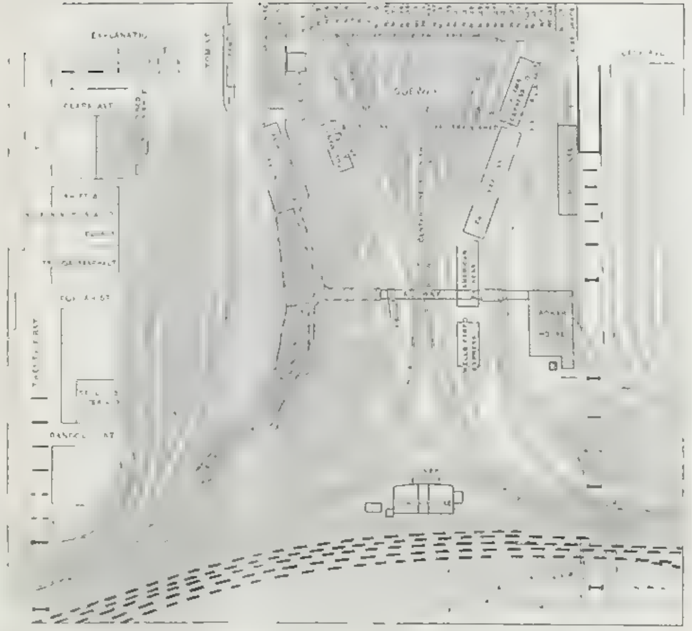


FIG. 3. PLAN, SHOWING PRESENT AND PROPOSED TRACKS IN VICINITY OF UNION STATION. DECEMBER 8, 1902

Scale, 1 inch = 300 feet

FIG. 4. PLAN OF YARDS BETWEEN WEST JEFFERSON AND COMPTON AVENUES, ST LOUIS. MARCH 27, 1903

Scale, 1 inch = 300 feet

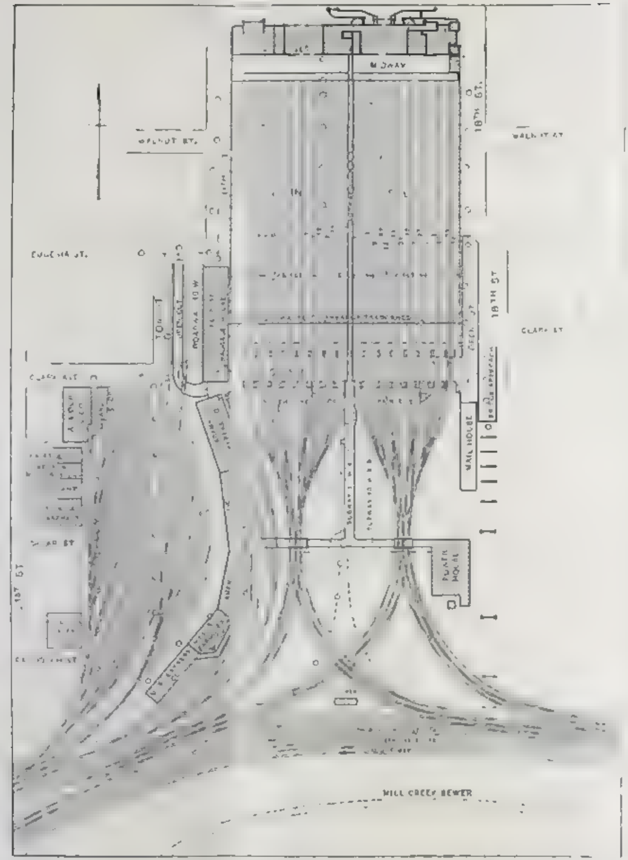


Fig. 5. Proposed Rearrangement, Union Station and Vicinity. January

Scale, 1 inch

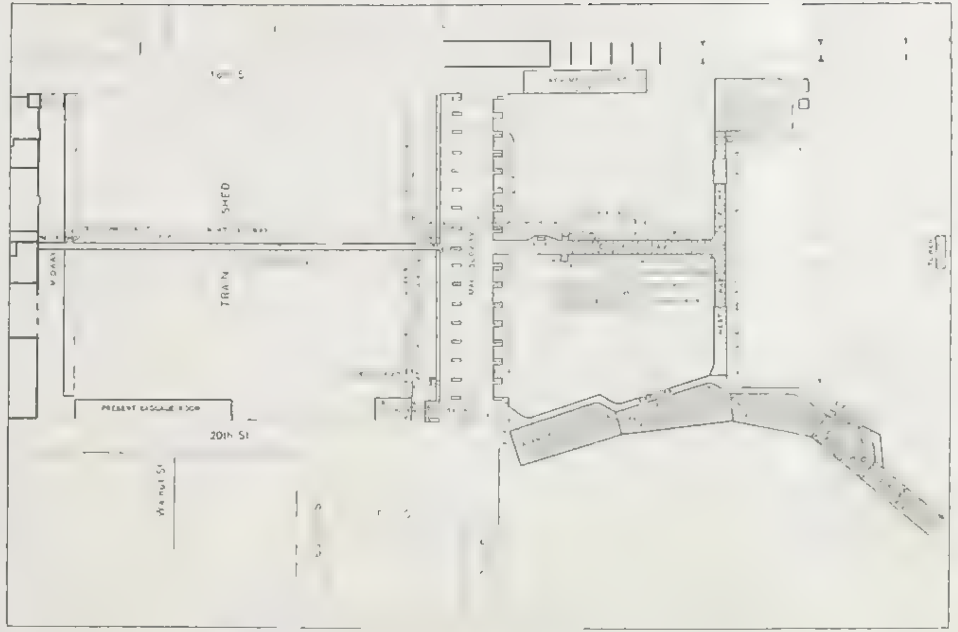


Fig. 6. General Layout of Subways, Union Station. July, 1903.

Fig. 7. General Plan and Sections of Main Subway, Union Station. July 21, 1903.

Scales 0.01 inch and 0.05 inch = 1 foot

new plan, and also shield the main subway built beneath the tracks. The train shed, exclusive of the midway (70 feet by 601 feet), will then be the largest in the country, if not in the world, and will cover (601 feet by 810 feet long) 11.18 acres and contain 6 miles of track.

In connection with all these Union Station improvements there is being built, to facilitate the handling of baggage, mail and express, a large system of underground subways. This subway scheme, embodying a very comprehensive plan for the rapid handling of all baggage and such portion of the mail and express business as is handled in the train shed on trucks, is believed to be an entirely new departure on such a large scale from any existing facility of the kind ever constructed in a large railway station. Its usefulness, in particular, is due to two general principles: First, that business requiring to be handled in a limited space of time is so located and concentrated as to give short hauls, and yet is not so crowded as to interfere with rapid movement; and, secondly, that the grade crossing of trucks and trains is eliminated. These two things are desirable at any station, but particularly so in St. Louis where trucking distances are very great and where interference of business, due to the crossing on grade of trucks and cars, is very serious.

The truck runway, crossing the tracks at this station, is near the south end of the train shed, and in the busy morning and evening periods, when trains are arriving and departing every minute or so, when switching movement is almost continuous and when rapid interchanges of large quantities of baggage, mail and express are necessary, the congestion is very great. Another feature which adds to the time of delays is the fact that it is necessary to cut long trains at this runway in order to leave the passage open. Then, when the train is still within a few minutes of leaving time, the train must be backed together and coupled up, in order to try air-brakes and connections. The subway plan will obviate all this interference and delay, and, because of its large scope, it should serve for a number of years the rapid and economical handling of this class of matter.

For convenience, the subway system is divided into the Main Subway and the North, South, East and West and Express Subways. (See Fig. 6.)

The Main Subway, paralleling the south end of the train shed and crossing each of the 32 tracks, runs from Eighteenth Street to Twentieth Street, a distance of 600 feet, and has a width of three ordinary streets, or about 120 feet. This 120 feet is divided, by

two rows of columns and the south wall, into a 40-foot baggage storeroom on the north side, equipped with an elevator between every two pairs of tracks; a 30-foot street adjacent for use of baggage wagons; another 30-foot street for use of mail and express wagons and trucks, and the south 20 feet for a line of elevators to be used for express and mail of all kinds. (See Fig. 7.)

These elevators are large enough for truckloads of baggage 4000 pounds in weight, and run at rate of 150 feet per minute from the subway floor either to the platform above or to the height of the platform of a car, 4 feet more. Approaches to the Main Subway are to be built from both Eighteenth Street and Twentieth Street, so that there will be a wagon entrance at both ends. Wagons loaded with baggage, mail or express can then come from any part of the city, drive into the main subway, stop immediately underneath the train for which its material is destined, load its contents either on trucks or on the elevator and have it raised rapidly to the cars already coupled on the trains. The north 40 feet of this subway is provided with the necessary gates, scales and check devices for the rapid handling of baggage as delivered.

The North Subway is a small subway running north and south under the train shed, from the head house to the Main Subway, between tracks 16 and 17. It is 12 feet wide by 9 feet clear, and is to be used for trucking hand baggage from a receiving check room, to be placed in the main waiting room, to the Main Subway. It will also serve to carry a number of pneumatic tubes between the same points, to be used as a means of transmitting baggage checks, similar to the operation of such tubes in department stores. There will be room also for steam pipes and wires, etc., up to the head house. The South Subway, running south from and in the center of the Main Subway, is merely a connecting link between it and the East and West Subways. It is 25 feet wide by 12 feet clear, and has along its walls niches for a sump, a transformer vault and an ice storehouse of small capacity.

The East Subway runs from the South Subway over to the power house, and, although 20 feet wide, has only 8 feet clearance for the passage of numerous pipes and wires from the power house.

The West Subway is a continuation of the East Subway, extending west from the South Subway to the express building. It is 20 feet wide by 12 feet clear.

The Express Subway is a small subway 12 feet wide by 14 feet clear, running parallel to all the express buildings and connecting same to the West and Main Subways. The basements of all the express buildings are on the same level as the subway floor.

Each express building is equipped with elevators, and it is expected that trucks will be taken from these buildings via the Express or West and South Subways to the elevators along the south wall of the Main Subway, and up these to the cars.

It is the intention to connect the basements of the baggage and mail buildings with the subways in the same manner as the express buildings.

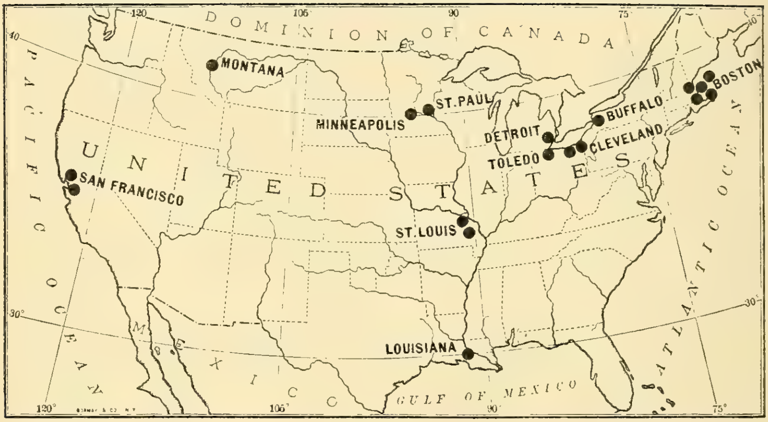
The above describes, in a hasty manner, the idea of the subway system, but I will not at this time go into details of its construction or design, but will merely add that the subways are to be roofed over and well paved. A heavy steel girder construction is employed to carry the tracks over the Main Subway.

The foregoing description of the various improvements covers, I believe, in a general way, the work being done or contemplated in the near future, but, in order to refrain from taking too much of your time, I have not mentioned many of the things embodied in the construction of yards and buildings under the very wheels of frequent traffic, or of details in design. The work is being executed at the cost of millions of dollars, and had not the city fathers been so unwise as to discourage improvements in railroad entrance ways to St. Louis it is likely that even still greater undertakings would have been built.

With the improvements and additions mentioned, however, and with present ones already in service, together with the additions and changes which nearly every road entering this territory is making on its own accord, I have no hesitancy in saying that St. Louis, in her railroad facilities, will be second to no city in the Union.

In making proper acknowledgment I should like to add that all these improvements are being made under the direct supervision of Mr. W. S. McChesney, Jr., president and general manager; Mr. Daniel Breck, general superintendent, and Mr. J. L. Armstrong, engineer, Maintenance of Way. Mr. E. F. Kearney is superintendent; Mr. T. N. Gilmore, master mechanic; Mr. G. F. Brooks, track supervisor, and Mr. J. A. Johnson, signal engineer, for the T. R. R. A. The St. Louis Belt and Terminal has Mr. B. E. Johnson for its chief engineer.

The writer, as assistant engineer to the Terminal Railroad Association, is particularly in charge of construction work in the St. Louis District, and has the able assistance of Mr. E. C. Dicke. Messrs. Brenneke & Fay have looked after steel-work design; Westinghouse, Church, Kerr & Co. are providing power, and Percival & Jones are installing elevators.



MAP

Showing the locations of the Societies forming

THE ASSOCIATION OF ENGINEERING SOCIETIES.

(Each dot represents a membership of one hundred, or fraction thereof over fifty.)

ASSOCIATION OF ENGINEERING SOCIETIES.

Articles of Association.

The following Articles of Association were adopted at a meeting held in Chicago, December 4, 1880. At this meeting there were present representatives of the

Western Society of Engineers,
Civil Engineers' Club of Cleveland,
Engineers' Club of St. Louis,

and the

Boston Society of Civil Engineers

was represented by letter.

FOR THE PURPOSE OF SECURING THE BENEFITS OF CLOSER UNION AND THE ADVANCEMENT OF MUTUAL INTERESTS, THE ENGINEERING SOCIETIES AND CLUBS HEREUNTO SUBSCRIBING HAVE AGREED TO THE FOLLOWING

ARTICLES OF ASSOCIATION.

ARTICLE I.

NAME AND OBJECT.

The name of this Association shall be "THE ASSOCIATION OF ENGINEERING SOCIETIES." Its primary object shall be to secure a joint publication of the papers and the transactions of the participating Societies.

ARTICLE II.

ORGANIZATION.

SECTION 1. The affairs of the Association shall be conducted by a Board of Managers under such rules and by-laws as they may determine, subject to the specific conditions of these articles. The Board shall consist of one representative from each Society of one hundred members or less, with one additional representative for each additional one hundred members, or fraction thereof over fifty. The members of the Board shall be appointed as each Society shall decide, and shall hold office until their successors are chosen.

SEC. 2. The officers of the Board shall be a Chairman and Secretary, the latter of whom may or may not be himself a member of the Board.

ARTICLE III.

DUTIES OF OFFICERS.

SECTION 1. The Chairman, in addition to his ordinary duties, shall countersign all bills and vouchers before payment and present an annual report of the transactions of the Board; which report, together with a

synopsis of the other general transactions of the Board of interest to members, shall be published in the JOURNAL OF THE ASSOCIATION.

SEC. 2. The Secretary shall be the active business agent of the Board and shall be appointed and removed at its pleasure. He shall receive a compensation for his services to be fixed from time to time by a two-thirds vote. He shall receive and take care of all manuscript copy and prepare it for the press, and attend to the forwarding of proof sheets and the proper printing and mailing of the publications. He shall have power, with the approval of any one member of the Board, to return manuscript to the author for correction if in bad condition, illegible or otherwise conspicuously deficient or unfit for publication. He shall certify to the correctness of all bills before transmitting them to the Chairman for counter-signature. He shall receive all fees and moneys paid to the Association and hold the same under such rules as the Board shall prescribe.

ARTICLE IV.

PUBLICATIONS.

SECTION 1. Each Society shall decide for itself what papers and transactions of its own it desires to have published, and shall forward the same to the Secretary.

SEC. 2. Each Society shall notify the Secretary of the minimum number of copies of the joint publications which it desires to receive, and shall furnish a mailing-list for the same from time to time. Copies ordered by any Society may be used as it shall see fit. Payments by each Society shall in general be in proportion to the number of copies ordered, subject to such modification of the same as the Board of Managers may decide, by a two-thirds vote, to be more equitable. Assessments shall be quarterly in advance, or otherwise, as directed by the Board.

SEC. 3. The publications of the Association shall be open to public subscription and sale, and advertisements of an appropriate character shall be received, under regulations to be fixed by the Board.

SEC. 4. The Board shall have authority to print with the joint publications such abstracts and translations from scientific and professional journals and society transactions as may be deemed of general interest and value.

ARTICLE V.

CONDITIONS OF PARTICIPATION.

SECTION 1. Any Society of Engineers may become a member of this Association by a majority vote of the Board of Managers, upon payment to the Secretary of an entrance fee of fifty cents for each active member, and certifying that these Articles of Association have been duly accepted by it. Other technical organizations may be admitted by a two-thirds vote of the Board, and payment and subscription as above.

SEC. 2. Any Society may withdraw from this Association at the end of any fiscal year by giving three months' notice of such intention, and shall then be entitled to its fair proportion of any surplus in the treasury, or be responsible for its fair proportion of any deficit.

SEC. 3. Any Society may, at the pleasure of the Board, be excluded from this Association for non-payment of dues after thirty days' notice from the Secretary that such payment is due.

ARTICLE VI.

AMENDMENTS.

These articles may be amended by a majority vote of the Board of Managers, and subsequent approval by two-thirds of the participating Societies.

ARTICLE VII.

TIME OF GOING INTO EFFECT.

These articles shall go into effect whenever they shall have been ratified by three Societies, and members of the Board of Managers appointed. The Board shall then proceed to organize, and the entrance fee of fifty cents per member shall then become payable.

These articles were adopted by the several Societies upon the following dates:

Engineers' Club of St. Louis, January 5, 1881.
Civil Engineers' Club of Cleveland, January 8, 1881.
Boston Society of Civil Engineers, January 19, 1881.
Western Society of Engineers, April 5, 1881.

The Board of Managers was organized at a meeting held in Cleveland, Ohio, January 11, 1881.

The following Societies have since certified their acceptance of the articles, and have become members of the Association of Engineering Societies:

Engineers' Club of Minneapolis, July, 1884.
Civil Engineers' Society of St. Paul, December, 1884.
Engineers' Club of Kansas City, January, 1887.
Montana Society of Civil Engineers, April, 1888.
Wisconsin Polytechnic Society, June, 1892.
Denver Society of Civil Engineers, January 24, 1895.
Association of Engineers of Virginia, February 1, 1895.
Technical Society of the Pacific Coast, March 1, 1895.
Detroit Engineering Society, January, 1897.
Engineers' Society of Western New York, January, 1898.
Louisiana Engineering Society, September 15, 1898.
Engineers' Club of Cincinnati, January, 1899.
Toledo Society of Engineers, January 11, 1904.

The Wisconsin Polytechnic Society withdrew from the Association in March, 1894.

The Western Society of Engineers withdrew in December, 1895.

The Engineers' Club of Kansas City disbanded at the close of 1896.

The Denver Society of Civil Engineers and the Association of Engineers of Virginia disbanded in 1898.

For the Engineers' Club of Cincinnati see footnote to Appendix F, Secretary's Annual Report for 1902, Vol. XXX, No. 1, page 57, January, 1903.

RULES.

(A) RULES OF THE BOARD OF MANAGERS.

Adopted, Chicago, June 11, 1881. Vol. I, No. 1, November, 1881, page 5.

1. Questions may be decided without a meeting of the Board, by correspondence. Motions shall be made and seconded and then forwarded to the President, and by him communicated to each member of the Board, to be voted upon by letter ballot.

2. Motion unanimously adopted favoring an independent monthly publication, embracing in each issue the proceedings and papers of each Society.

3. On motion, it was decided that the matter of each Society should be placed separately in the pamphlet, under the proper heading, the positions to be arranged in the order of the rate of organization.

Adopted, New York, June 22, 1882. Vol. II, No. 3, January, 1883, page 107.

4. Each assessment proportioned to the Societies on the basis of the number of copies of the JOURNAL taken at the time the assessment is made.

Adopted, New York, September 4, 1884. Vol. III, No. 12, October, 1884, page 329.

5. That the names and addresses of the officers of each Society be printed upon the second page of the cover of the JOURNAL.

6. That in the opinion of this Board it is desirable that papers read before the Societies of this Association should not be published in professional periodicals previous to being published by the Association; that there is no objection to publishing them in whole or in part in local newspapers.

7. That the Secretary be instructed to insert in the JOURNAL the following: Editors reprinting articles from this JOURNAL are requested to credit both the JOURNAL and the Society before which such articles were read.

8. That the Chairman be authorized to arrange for publishing in the JOURNAL an index of engineering reports and Society transactions, and abstracts of such reports and transactions as may be found desirable.

Adopted, Chicago, September 11, 1891. Vol. X, No. 10, October, 1891, page 511.

9. A discussion on the value and quantity of matter sent to the Secretary for publication resulted in the opinion that final control should rest with the Board.

The following suggestions of a committee were adopted:

10. That, beginning with the January number, 1892, a Secretary be employed at a salary of not to exceed $600 per annum, who shall conduct all the correspondence and other business pertaining to the office, and who shall also be employed to publish the JOURNAL at standard current prices, keeping a strict account of all receipts and expenditures, and render an account of the same to the Chairman of this Board, on whose approval the accounts may be allowed.

11. That the Chairman of the Board should audit all bills and accounts, and collect from each Society, quarterly, their pro rata of the estimated net cost of the publication, and at the end of each volume he should make a report to the Board, to be published in the JOURNAL, giving a classified statement of all receipts and expenditures, which report should be subject to the inspection and approval of the Board.

12. That each Society in the Association be allowed one-half the receipts from all advertisements sent in by its Secretary to the JOURNAL, and that such sums be placed to its credit on the Secretary's books and deducted from its pro rata portion of the cost of publication, and that the same commission be allowed the Secretary of the Board, in addition to his salary, on all new advertisements he may procure.

Adopted, Chicago, August 3, 1893. Vol. XII, No. 7, July, 1893, page 380.

13. Rules governing the Election of Officers of the Board of Managers of the Association of Engineering Societies:

(1) The term of office of the Chairman and that of the Secretary and Treasurer shall be two (2) years, and shall begin on January 1st, of the even years, but they shall remain in office till their successors are chosen.

(2) The election of officers shall occur at any time at a called meeting of the Board, or by letter ballot, between October 1st and December 1st of the odd years.

(3) If the election is by letter ballot, without a meeting of the Board, the Chairman shall, through the Secretary, give notice of such election prior to October 10th of the odd years, and shall also give notice, at the same time, of the appointment of two tellers in one city, members of the Board, but not officers of the same, to whom the votes shall be mailed. These tellers shall open the ballots on November 1st, and report the result to the Chairman of the Board. If no one has received a majority of the votes cast for either office, the Chairman shall order a new ballot, similar to the first, but limiting the names voted for to the two receiving the highest number of votes for that office on the first ballot. The tellers shall open the second ballot on December 1st, and report as before. The Chairman shall then announce the result of the ballot to all the members, and the new officers shall act from the beginning of the following calendar year.

(4) Vacancies in the offices of the Board may be filled at any time, either by a meeting of the Board or by letter ballot as described in Section 3. In a case of a vacancy occurring, the remaining officer shall discharge the duties of both till the vacancy is duly filled.

Other rules adopted August 3, 1903.

14. That each Society, member of this Association, be credited with 90 per cent. of the receipts from all advertisements sent in to the JOURNAL by said Society until January 1, 1895.

15. That future JOURNALS be issued with cut leaves.

16. That the Constitution be reprinted in portable form, with all subsequent additions, together with report of these proceedings.

17. That the Secretary be requested to see that cuts published with linear scales bear metric scales, unless objection is made by the authors.

Adopted by letter ballot, submitted May 15, 1894.

18. Advertising rates of the JOURNAL increased 50 per cent.

19. Proportion of the net proceeds of advertisements credited to any Society limited to 50 per cent.

20. Number of extra copies of the JOURNAL sent to members of the Board made five.

21. Number of copies of the JOURNAL to be printed, over and above the mailing list, 250.

Adopted by letter ballot, submitted December 18, 1894.

22. Secretary authorized to print advance copies of papers, and send out the same for discussion to all members of the Association indicated to him by the writer, or otherwise, or to such as may request copies, provided the Society in which the paper originates is charged with the extra cost of same.

Adopted by letter ballot, submitted June 20, 1895.

RULES PROPOSED BY THE WESTERN SOCIETY OF ENGINEERS.

23. The object of the JOURNAL is to print the papers and transactions of the Societies, and it is not for the purpose of establishing a professional monthly magazine.

24. The amount of matter must be restricted to that which can be published at a cost of $3 per annum for each person on the mailing list of each Society, except as hereinafter provided.

25. No Society having dues or assessments in arrears for more than ninety days after notice, or whose arrearages shall at any time exceed $2 per member, shall participate in the privileges of the Association; nor shall it be in the power of the Board of Managers to deviate from enforcing this rule.

26. The Association shall not have power to make any contract or incur any liabilities which will bind the Association to an expenditure beyond the limitations specifically permitted by the Articles of Association.

27. The Association shall not publish in the JOURNAL any other matter than the papers and transactions of the Societies, if it shall appear that by so doing the cost will exceed $3 per annum per member of the Societies.

28. The Association may secure subscriptions to the JOURNAL, and furnish reprints, with a view to profit to the Association.

Adopted by letter ballot, submitted October 15, 1897.

29. The issue of five copies of the JOURNAL monthly to each member of the Board of Managers discontinued.

30. The Secretary authorized to send, gratis, to any Society belonging to the Association as many extra copies of any issue of the JOURNAL as it shall notify him it desires, not exceeding five copies for each representative it has on the Board of Managers.

Adopted by letter ballot, submitted September—, 1898.

31. To allow the Society securing same 90 per cent. (based on present rates) of the receipts from new advertisements secured for the JOURNAL.

32. To allow authors of papers appearing in the JOURNAL to append to their names (in addition to "Member of ——— Society") such college degrees and scientific society memberships as they may choose.

33. To allow authors of papers appearing in the JOURNAL to append a statement of their present or past professional position, in addition to "Member of ——— Society."

Adopted by letter ballot, submitted December 5, 1898.

34. All ballots close six weeks after the date of mailing blanks to the members of the Board of Managers.

Adopted by letter ballot, No. 103, submitted November 7, 1901.

35. That the Secretary be authorized to furnish to the author of any paper, at 15 cents each, additional copies of the issue of the JOURNAL containing such paper, provided due notice be given in advance, stating the number of such extra copies required.

(B) RULINGS BY CHAIRMEN.

36. Societies which enter must require all their members to take the JOURNAL. J. B. Johnson, November 24, 1894.

37. "I will consent (for reasons stated) to allow them (the Association of Engineers of Virginia) to decide how many copies of the JOURNAL they wish to take (not less than 25), provided they will be strictly regular in their compliance with the other requirements of the Articles of Association." J. B. Johnson, November 28, 1894.

38. Authorizing the publication in the JOURNAL of lists of members of the several Societies, with their occupations and addresses. George D. Shepardson, December 5, 1898.

39. Providing for a periodical audit of the accounts of the Secretary. George D. Shepardson, December 16, 1899.

INDEX TO ARTICLES OF ASSOCIATION AND RULES.

NOTE.—"A" means Articles of Association. "A I 1" means Articles of Association, Article I, Section 1. "R" means Rule or Rules.

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ABSTRACTS OF PROCEEDINGS.

FROM MEETING OF REPRESENTATIVES OF THE SOCIETIES.

Chicago, December 4, 1880,

to

December 31, 1904.

MEETING OF REPRESENTATIVES OF SOCIETIES.

Chicago, December 4, 1880.

See Journal, Vol. I, No. 1, November, 1881, page 1.

Western Society of Engineers, represented by Benezette Williams, L. P. Morehouse and John W. Weston.

Civil Engineers' Club of Cleveland, represented by M. E. Rawson and A. M. Wellington.

Engineers' Club of St. Louis, represented by Chas. A. Smith.

Boston Society of Civil Engineers, represented by letter.

Benezette Williams, Chairman; A. M. Wellington, Secretary.

Articles of Association adopted.

ABSTRACT OF RECORDS OF MEETINGS OF THE BOARD OF MANAGERS.

Cleveland, Ohio, June 11, 1881.

See Journal, Vol. I, No. 1, November, 1881, page 5.

Election of Benezette Williams, Chairman of Board of Managers, confirmed.

M. E. Rawson elected Secretary pro tem.

Resolutions unanimously adopted in favor of independent monthly publication.

Matter submitted by each Society to be placed separately in the pamphlet, under the proper heading; the positions to be arranged in the order of the date of organization. Form of title page adopted

Provision made for decision of questions by letter ballot.

Scale of prices for advertisements adopted.

Between the meeting of June 11, 1881, and the issue of the first number of the Journal (November 1, 1881), the Board completed its organization by the election of H. G. Prout as Secretary, and arranged to have the work of publication carried on under his charge at stipulated rates.

New York, June 22, 1882.

See first annual report of Chairman, January 2, 1883, published in Journal, Vol. II, No. 3, January, 1883, page 107.

Rule adopted in the manner of levying assessments, by which each assessment is proportioned to the Societies on the basis of the number of copies of the Journal taken at the time the assessment is made.

Address issued "To the Engineers of America." This address is printed in Vol. I, June, 1882, page 289.

New York, September 4, 1884.

See Journal, Vol. III, No. 12, October, 1884, page 329.

Assessment of $3 ordered, to be paid in instalments of $1; each instalment to be based on the mailing list at the time the instalment is called for, and to be subject to the order of the Chairman.

Names and addresses of officers of each Society ordered printed upon the second page of the cover of the Journal.

Resolved, "That in the opinion of this Board it is desirable that papers read before the Societies of this Association should not be published in professional periodicals previous to being published by the Association. That there is no objection to publishing them in whole or in part in local newspapers.

Secretary instructed to insert in the Journal the following: "Editors reprinting articles from this Journal are requested to credit both the Journal and the Society before which such articles were read."

Chairman authorized to arrange for publishing in the Journal an index of engineering reports and Society transactions, and abstracts of such reports and transactions as may be found desirable.

Contract with Atkin & Prout, for printing the Journal, continued.

Chicago, April 15, 16, 1887.

See Journal, Vol. VI, No. 5, May, 1887, page 215.

Proposition from H. G. Prout, Secretary, for printing the Journal, accepted.

Engineers' Club of Kansas City admitted to membership in Association.

Benezette Williams and H. G. Prout unanimously re-elected Chairman and Secretary, respectively.

Ordered that Index Department remain under the general control of J. B. Johnson.

Action taken, looking to the formation of "an organic confederation of engineering societies."

Ordered that the official documents of the Council of Engineering Societies upon National Public Works be published in the Journal.

Assessment authorized.

Chicago, December 3, 4, 1889.

See Journal, Vol. VIII, No. 12, December, 1889, page 589.

Amendments to the Articles of Association adopted, for submission to the Societies; providing:

1. For the submission to the Societies, by the Board, at the request of any Society, "any question of scientific, technical or professional interest," the several Societies to report to the Board, and the Board to formulate and publish, in the Journal, "a general report embodying the facts and in accordance with the general sense and tenor of the local reports."

2. For recommendation to the Societies, by the Board of "recommendations on any subject affecting the policy of the Association or the mutual relations of the participating Societies. Adoption of such recommendations by two-thirds of the Societies to make them 'the law of the Association and binding upon all participating Societies.' "

These amendments were not subsequently ratified by the Societies.

Proposition from John W. Weston, to publish the Journal and perform the duties of the Secretary in consideration of $2.75 per annum from each Society member, and $3 from each outside subscriber, accepted.

Committee appointed "to prepare an address to the various engineering societies of this country on the subject of a national organization."

Benezette Williams unanimously re-elected Chairman.

John W. Weston unanimously elected Secretary.

CHICAGO, SEPTEMBER 11, 1891.

See JOURNAL, Vol. X, No. 10, October, 1891, page 511.

A discussion "on the value and quantity of matter sent to the Secretary for publication" resulted in "the opinion that final control should rest with the Board."

Resolved:

1. That Mr. Weston be requested to continue the publication of the JOURNAL to the close of the current year and volume.

2. That, "beginning with the January number, 1892, a Secretary be employed at a salary not to exceed $600 per annum"; said Secretary to "conduct all the correspondence and other business pertaining to the office" and to publish the JOURNAL at standard current prices."

3. That the Chairman audit all bills and accounts, and collect from each Society quarterly its pro rata of the estimated net cost of the publication, and publish annually in the JOURNAL his report to the Board on this subject.

4. That 50 per cent. commission be allowed to each Society and to the Secretary for advertisements obtained by them for the JOURNAL.

Benezette Williams and John W. Weston re-elected Chairman and Secretary, respectively.

Assessment authorized.

CHICAGO, AUGUST 1, 2, 3, 1893.

See JOURNAL, Vol. XII, No. 7, July, 1893, page 380.

Resignation of Benezette Williams, as Chairman, accepted.

RULES ADOPTED, GOVERNING ELECTION OF OFFICERS.

1. President and Secretary elected for two years each, beginning January 1st of each even year, "but they shall remain in office till their successors are chosen."

2. Election at any called meeting of the Board, or by letter ballot, between October 1st and December 1st of the odd years.

3. If by letter ballot, "the Chairman shall, through the Secretary, give notice of such election prior to October 10th of the odd years," appointing two tellers in one city, members, but not officers, of the Board. Ballots to be opened November 1st and result reported to Chairman. Provision for failure to elect on first ballot.

4. Vacancies may be filled at any time, at a meeting of the Board, or by letter ballot, the remaining officer to discharge the duties of both offices pending the vacancy.

Ordered:

That each Society be allowed 90 per cent. of receipts from its advertisements until January 1, 1895.

That future JOURNALS be issued with cut leaves.

"That the Constitution be reprinted in portable form, with all subsequent additions, together with report of these proceedings."

"That the Secretary be requested to see that cuts published with linear scales bear metric linear scales, unless objection is made by the authors."

Assessment ordered, to cover expenses of members attending meeting.

LETTER BALLOTS OF THE BOARD OF MANAGERS.

Ballot Counted November 1, 1893.

See report for 1893, by Benezette Williams, Retiring Chairman, dated February 6, 1894. Journal, Vol. XIII, No. 1, January, 1894.

J. B. Johnson elected Chairman for 1894-95.

John C. Trautwine, Jr., elected Secretary for 1894-95.

Questions Submitted May 15, 1894.

Results Announced June 1, 1894.

1. Shall the advertising rates of the Journal be increased 50 per cent.?

Yes: Waddell, Benjamin, Appleton, Nichol, Williams, Morris, Russell.

No: Keerl, Manley, Freeman, Tinkham.

Yes, 7; No, 4; doubtful, Pike (not at present). Carried.

2. Shall the proportion of the net proceeds of advertisements credited to any Society be limited to 50 per cent.?

Yes: Russell, Morris, Williams, Nichol, Appleton, Benjamin, Pike, Waddell, Keerl.

No: Tinkham, Freeman, Manley.

Yes, 9; No, 3. Carried.

3. Shall the number of extra copies of the Journal sent to members of the Board be made five?

Yes: Manley, Freeman, Tinkham, Waddell, Pike, Benjamin, Appleton, Nichol, Williams, Morris, Russell.

No: Keerl.

Yes, 11; No, 1. Carried.

4. What number of extra copies of the Journal over and above mailing list shall be printed?

300: Russell, Williams, Waddell, Tinkham, Manley, Freeman.

200: Morris (or 15 per cent.), Appleton, Benjamin.

200 to 300: Nichol.

250: Pike.

250 to 300: Keerl.

Carried, 250.

5. Shall the Board purchase 250 bound copies of the Engineering Index for $375?

Yes: Waddell, Benjamin, Williams, Morris, Russell.

No: Keerl, Freeman, Manley, Tinkham, Pike.

No vote: Appleton, Nichol.

Yes, 5; No, 5. Lost.

Questions Submitted December 18, 1894.

Results Announced January 7, 1895.

1. Shall the December number of the Journal include a reasonable amount of literary matter in addition to the Annual Index Summary?

Yes: Freeman, Manley, Tinkham, Waddell, Nichol, Williams, Johnson, Barnes and Keerl.

No: Appleton, Morris.

Yes, 9; No, 2. Carried.

2. Shall a special assessment be levied, after the expenses for the year 1894 have been determined, to cover such deficit as remains for this year?

Yes: Unanimous. Carried.

3. May individual Societies be admitted to membership in the Association without paying the 50 cents initiation fee for their entire membership, provided this fee be paid by as many as take the JOURNAL, and provided, further, that this number be not less than 25?

Yes: Freeman, Waddell, Nichol and Morris.

No: Manley, Tinkham, Johnson, Appleton, Barnes and Keerl.

Doubtful: Williams.

Yes, 4; No, 6; Doubtful, 1. Lost.

4. Shall the Secretary be authorized to print advance copies of papers and send out the same for discussion to all members of the Association indicated to him by the writer, or otherwise, or to such as may request copies, provided the Society in which the paper originates is charged with the extra cost of same?

Yes: Johnson, Freeman, Manley, Tinkham, Appleton, Barnes and Keerl.

No: Morris.

Doubtful: Waddell, Nichol and Williams.

Yes, 7; No, 1; Doubtful, 3. Carried.

5. Or, shall advance copies of important papers be printed and circulated as indicated in 4, at the expense of the Association?

Yes: Waddell and Barnes.

No: Freeman, Manley, Tinkham, Appleton, Johnson, Morris and Keerl.

Doubtful: Williams. (Nichol does not vote.)

Yes, 2; No, 7; Doubtful, etc., 2. Lost.

6. Shall the Chairman be authorized to try and effect an arrangement whereby the Index Department shall hereafter be conducted by one or more of the national societies?

Yes: Manley, Tinkham and Keerl.

No: Appleton, Johnson, Waddell, Williams, Barnes and Morris.

Doubtful: Freeman. (Nichol does not vote.)

Yes, 3; No, 6; Doubtful, etc., 2. Lost.

7. Is it desirable to arrange for an annual meeting of the members of the Association? . . . . Is it practicable? . . . .

(A) Desirable?

Yes: Tinkham, Appleton, Keerl and Williams.

No: Barnes and Morris.

Doubtful: Waddell and Manley. (Nichol does not vote.)

Yes, 4; No, 2; Doubtful, 2. Lost.

(B) Practicable?

Yes: Keerl.

No: Freeman, Tinkham, Appleton, Williams, Barnes and Morris.

Doubtful: Waddell. (Nichol does not vote.)

Yes, 1; No, 6; Doubtful, etc., 2. Lost.

8. Shall the "Contribution Box" and the "Library," as conducted by our Secretary in the JOURNAL, be discontinued, with an annual saving of about $200?

Yes: Appleton.

No: Freeman, Manley, Tinkham, Waddell, Williams, Barnes, Johnson, Morris and Keerl. (Nichol does not vote.)

Yes, 1; No, 9; (?), 1. Lost.

9. Would you attend a meeting of this Board if appointed to be held in New York City or Philadelphia, on or about January 16th next?

Yes: Freeman, Tinkham and Manley.

No: Appleton, Johnson, Nichol, Williams, Barnes, Morris and Keerl.

Doubtful: Waddell.

Yes, 3; No, 7; Doubtful, 1. Lost.

10. Shall the Index Department of the JOURNAL be discontinued regardless of the action of the national societies on this subject, with a total annual saving, as estimated by the Secretary for 1894, of $900, out of a total cost for 1894 of $5300? (Members might consult their Societies on this subject.)

Yes: Appleton, Nichol and Keerl.

No: Freeman, Tinkham, Waddell, Williams, Johnson and Morris.

Doubtful: Manley. (Barnes does not vote.)

Yes, 3; No, 6; Doubtful, etc., 2. Lost.

Voting, ten members, viz: Messrs. Tinkham, Freeman, Manley, Williams, Nichol, Appleton, Waddell, Johnson, Barnes (St. Louis) and Morris.

QUESTION SUBMITTED JANUARY 3, 1895.

Result Announced ——.

Admission of Association of Engineers of Virginia to membership in the Association of Engineering Societies.

Yes: Keerl, Williams, Barnes, Morris, Tinkham, Manley, Freeman, Benjamin, Pike, Waddell and Nichol.

Yes, 11. Carried.

QUESTION SUBMITTED JANUARY 7, 1895.

Result Announced ——.

Admission of the Denver Society of Civil Engineers to membership in the Association of Engineering Societies.

Yes: Keerl, Williams, Barnes, Tinkham, Manley, Freeman, Benjamin, Waddell, Nichol and Woodman.

No: Appleton.

Yes, 10; No, 1. Carried.

QUESTIONS SUBMITTED MARCH 2, 1895.

Results Announced ——.

1. On the admission of the Technical Society of the Pacific Coast to membership in the Association of Engineering Societies.

Yes: Benjamin, Williams, Pike, Woodman, Keerl, Wason, Barns, Barnes, Johnson, Manley, Tinkham, Freeman, Churchill, Waddell, Nichol, Martin and Appleton.

Yes, 17. Carried.

2. On the acceptance of fifty bound copies of the volume of Index Notes from Mr. Weston, in payment of his indebtedness to the Association to the amount of $72.

Yes: Benjamin, Williams, Pike, Woodman, Keerl, Barns, Barnes, Waddell, Nichol and Appleton.

No: Wason, Manley, Tinkham, Freeman and Martin.

Yes, 10; No, 5. Carried.

3. On authorizing the Chairman and Secretary to decline to publish papers which have already been published either in full, or in very full abstract, in any engineering journal.

No: Williams, Woodman, Keerl, Wason, Barnes, Manley, Tinkham, Freeman, Churchill, Nichol and Waddell.

No, 11. Lost.

QUESTIONS SUBMITTED JUNE 20, 1895.

Results Announced July 11, 1895.

Rules for the government of the Board of Managers, proposed by the Western Society of Engineers, and their adoption moved by the members of the Board from that Society:

(For vote in detail, see below.)

1. The object of the JOURNAL is to print the papers and transactions of the Societies, and it is not for the purpose of establishing a professional monthly magazine.

Yes, 11; No, 4. Carried.

2. The amount of matter must be restricted to that which can be published at a cost of $3 per annum for each person on the mailing list of each Society, except as hereinafter provided.

Yes, 8; No, 7. Carried.

3. The amount of matter which each Society is entitled to have published to be in direct proportion to the amount it contributes to the cost of publication.

No, 15. Lost.

4. Any Society desiring to publish matter in excess of its proportion may publish such matter by paying the full extra cost thereof.

No, 15. Lost.

5. No Society having dues or assessments in arrears for more than ninety days after notice, or whose arrearages shall at any time exceed $2 per member, shall participate in the privileges of the Association; nor shall it be in the power of the Board of Managers to deviate from enforcing this rule.

Yes, 10; No, 6. Carried.

6. A paper shall be accredited to the Society before which it is read, but the author, if a member of any Society or Societies of the Association, shall be credited with such membership, and none other.

Yes, 7; No, 8. Lost.

7. The Association shall not have power to make any contracts or incur any liabilities which will bind the Association to an expenditure beyond the limitations specifically permitted by the Articles of Association.

Yes, 10; No, 5. Carried.

8. The Secretary of the Association shall not have authority to edit any papers sent for publication, except by specific consent of the Society furnishing the paper.

No, 15. Lost.

9. Advertisements may be received by and inserted in the JOURNAL by its management, but all contracts therefor must terminate in the calendar year of the contract.

Yes, 6; No, 10. Lost.

10. The Association shall not publish in the JOURNAL any other matter

than the papers and transactions of the Societies, if it shall appear that by so doing the cost will exceed $3 per annum per member of the Societies.

Yes, 8; No, 7. Carried.

11. The Association may secure subscriptions to the JOURNAL, and furnish reprints, with a view to profit to the Association.

Yes, 12; No, 4. Carried.

12. The Western Society has also passed the following resolution:

"*Resolved*, That the Board of Managers of the Association of Engineering Societies be requested to make to this Society a financial statement for the first quarter of the present year, and for each quarter thereafter, showing the cost of the JOURNAL, the number of members in each Society on the JOURNAL mailing list, the amount of money paid (to the Association) by each Society and the amount any Society is delinquent."

The members will please observe that this is a request made to the Board, and is not a part of the rules of the Board whose adoption has been moved and are given above. The Chairman will take the liberty of reminding the members of the Board that the preparation of a quarterly financial statement involves a very considerable amount of additional work on the part of our Secretary, and perhaps more than he can afford to give for the salary paid. You will please indicate your vote, also, on this request, as to whether or not it shall become a rule of the Board.

(Note, signed by Benezette Williams, Member, Board of Managers.)

Yes, 1; No, 15. Lost.

VOTE ON TWELVE QUESTIONS, AS ABOVE.

		QUESTION NO.											
Society.	Member of Board.	1	2	3	4	5	6	7	8	9	10	11	12
Western	Williams,			N	N	Y	Y	N	N	N		Y	N
	Barnes,	Y	N	N	N	Y	N	Y	N	N	Y	Y	Y
	Nichol,	Y	Y			Y	Y	Y		Y	Y	Y	N
Boston	Brooks,	N	N	N	N	N	N	N	N	N	N	N	N
	Manley,	N	Y	N	N	N	N	N	N	N	N	N	N
	Tinkham,	Y	N	N	N	Y	N	Y	N	N	N	Y	N
	Freeman,	N	N	N	N	N	N	N	N	N	N	N	N
Cleveland	Ritchie,	Y	Y	N	N	Y	Y	Y	N	Y	Y	Y	N
St. Louis	Johnson,	Y	N	N	N	Y	N	Y	N	N	N	Y	N
	Barns,	Y	Y	N	N	N	N	Y	N	N	Y	Y	N
St. Paul	Woodman,	Y	Y	N	N	Y	Y	Y	N	Y	Y	Y	N
Minneapolis	Pike,	Y	Y	N	N	N			N	N	Y	Y	N
Kansas City	Waddell,	Y	N	N	N	Y	Y	Y	N	Y	N	Y	N
Montana	Keerl,	Y	Y	N	N	Y	Y	Y	N	Y	Y	Y	N
Pacific Coast	Hasson,	N	N	N	N	N	N	N	N	N	N	N	N
Virginia	Churchill,	Y	Y	N	N	Y	Y	Y	N	Y	Y	Y	N
Denver													
Totals:	Yes,	11	8			10	7	10		6	8	12	1
	No,	4	7	15	15	6	8	5	15	10	7	4	15

QUESTION SUBMITTED OCTOBER 17, 1895.

Result Announced November 11, 1895.

Nominations for officers for 1896-97:

For Chairman—S. E. Tinkham, nominated by Fred Brooks, John R. Freeman and Henry Manley.

James Ritchie, nominated by the Civil Engineers' Club of Cleveland.

J. B. Johnson, nominated by James Ritchie and James S. Keerl. Nomination declined.

For Secretary—John C. Trautwine, Jr., Nominated by Fred Brooks, John R. Freeman, Henry Manley, James Ritchie, James S. Keerl and the Civil Engineers' Club of Cleveland.

The vote:

For Chairman—S. E. Tinkham, 9 votes; James Ritchie, 3 votes.

For Secretary—John C. Trautwine, Jr., 12 votes.

Tellers—Prof. J. P. Johnson and Mr. W. E. Barns, of the Engineers' Club of St. Louis.

Questions Submitted December 2, 1895.

Results Announced ——.

1. Shall the price of the Journal hereafter be changed to subscribers?

2. Shall Mr. John R. Dunlap, Editor of the *Engineering Magazine*, be given permission to republish, in book form, the Index Notes which have appeared in the Journal for the last four years, or since the previous bound Index Summary appeared?

No record of vote on these questions.

Question Submitted January 1, 1897.

Result Announced ——.

On the admission of the Detroit Engineering Society to membership in the Association of Engineering Societies.

Yes: Hermann, Hasson, Manley, Brooks, Freeman, Tinkham, Culley, Churchill, Johnson, Hyde, Woodman, Campbell, Vischer, Shepardson and Keerl.

Yes, 15. Carried.

Questions Submitted October 15, 1897.

Results Announced November 11, 1897.

1. Nominations for officers for 1898-99:

For Chairman—Fred Brooks, of Boston, nominated by John W. Langley, member of the Civil Engineers' Club of Cleveland.

George D. Shepardson, of Minneapolis, nominated by Edwin E. Woodman, of the Civil Engineers' Society of St. Paul.

For Secretary—John C. Trautwine, Jr., nominated by Messrs. Langley and Woodman.

Tellers—Messrs. Henry Manley and John R. Freeman, of the Boston Society of Civil Engineers.

2. That the issue of five copies of the Journal monthly to each member of the Board of Managers be discontinued.

Moved by Mr. Edwin E. Woodman, member of the Board for the Civil Engineers' Society of St. Paul.

3. That the Secretary be authorized to send, gratis, to any Society belonging to the Association, as many extra copies of any issue of the Journal as it shall notify him it desires not exceeding five copies for each representative it has on the Board of Managers.

Moved by Mr. S. E. Tinkham, Chairman.

4. On the advisability of reducing the amount of the fourth quarterly assessment, for the year 1897, from 75 cents (as usual) to 25 cents.

THE VOTE.

QUESTION 1—For Chairman:

Whole number of ballots	14
Informal	1
	13
Necessary for a choice	7
Prof. George D. Shepardson has	8
Mr. Fred Brooks has	5

For Secretary:

Whole number of ballots	14
Mr. John C. Trautwine, Jr., has	14

QUESTIONS 2, 3, and 4:

Whole number of votes received	14
One ballot was not signed	1
Total number of votes counted	13

On Question 2, 9 votes were in the affirmative and 4 in the negative.

On both Questions 3 and 4, the vote was unanimously in the affirmative.

The unsigned ballot was in the affirmative on all the questions, so the result would not be changed if it were counted.

QUESTION SUBMITTED JANUARY 15, 1898.

Result Announced March 29, 1898.

Admission of the Engineers' Society of Western New York to membership in the Association of Engineering Societies.

Yes: Brooks, Wilson, Churchill, Tinkham, Woodman, Hyde, Freeman, Keerl, Johnson, Henny, Jones, Manley and Livingston.

Yes, 13. Carried.

January 15, 1898, Chairman Shepardson wrote: "About the proportion of the membership in each Society that must be assessed and to which the JOURNAL is sent: In a few cases only a part of the membership has been assessed, to make it possible for certain Societies to join or to retain membership. Do you wish to lay down a rigid interpretation of the rule or to leave it to the discretion of the Board in special cases?"

Mr. John R. Freeman replies: "I favor a liberal interpretation of the rule, and would leave any special case to the discretion of the Board."

QUESTIONS SUBMITTED SEPTEMBER —, 1898.

Results Announced December 5, 1898.

1. To allow the Society securing same, 90 per cent. (based on present rates) of the receipts from new advertisements secured for the JOURNAL.

Yes: Brackett, Johnson, Thacher, Woodman, Shepardson, Tinkham, Howe, Brooks, von Geldern, Tutton and Manley.

No: Henny, Freeman and Churchill.

Yes, 11; No, 3. Carried.

2. To allow authors of papers appearing in the JOURNAL to append to their names (in addition to "Member of ——— Society") such college degrees and scientific society memberships as they may choose.

Yes: Henny, Johnson, Freeman, Thacher, Woodman, Howe, Brooks, von Geldern and Tutton.

No: Brackett, Churchill, Shepardson, Tinkham and Manley.

Yes, 9; No, 5. Carried.

3. To allow authors of papers appearing in the JOURNAL to append a statement of their present or past professional position in addition to "Member of ——— Society."

Yes: Henny, Freeman, Woodman, Shepardson, Howe, Brooks, von Geldern, Tutton and Manley.

No: Brackett, Johnson, Churchill, Thacher and Tinkham.

Yes, 9; No, 5. Carried.

4. To hold Secretaries of local Societies responsible for the accuracy of titles, society memberships and professional positions of authors of papers sent for publication in the JOURNAL.

Yes: Henny, Johnson, Freeman and Shepardson.

No: Brackett, Churchill, Thacher, Woodman, Tinkham, Howe, Brooks, Tutton and Manley.

Yes, 4; No, 9. Lost.

5. To have the Secretary prepare brief sketches of authors of papers in the JOURNAL.

Yes: Freeman, Shepardson and Howe.

No: Henny, Brackett, Johnson, Churchill, Thacher, Woodman, Tinkham, Brooks, von Geldern, Tutton and Manley.

Yes, 3; No, 11. Lost.

QUESTION SUBMITTED SEPTEMBER —, 1898.

Result Announced, September 10, 1898.

Admission of the Louisiana Engineering Society to membership in the Association of Engineering Societies.

Yes: Henny, Brackett, Johnson, Manley, Tutton, von Geldern Brooks, Howe, Tinkham, Freeman, Woodman, Shepardson, Churchill and Thacher.

Yes, 14. Carried.

QUESTIONS SUBMITTED DECEMBER 5, 1898.

Results Announced ——.

1. Admission of the Engineers' Club of Cincinnati to membership in the Association of Engineering Societies.

Yes: Johnson, Coleman, von Geldern, Henny, Ritchie, Freeman, Brooks, Thacher, Woodman, Tutton, Tinkham, Churchill, Brackett, Howe, Manley and Shepardson.

Yes, 16. Carried.

2. All ballots close six weeks after the date of mailing blanks to the members of the Board of Managers.

Yes: von Geldern, Johnson, Shepardson, Manley, Churchill, Howe, Brackett, Tinkham, Tutton, Woodman, Thacher, Brooks, Ritchie, Freeman, Coleman and Henny.

Yes, 16. Carried.

QUESTION SUBMITTED NOVEMBER 28, 1899.

Result Announced January 3, 1900.

Election of officers for 1900-1901:

For Chairman—James Ritchie, of the Civil Engineers' Club of Cleveland. 12 votes.

S. E. Tinkham, of Boston Society of Civil Engineers, 1 vote.

George D. Shepardson, of Civil Engineers' Society of St. Paul, 1 vote.

For Secretary—John C. Trautwine, Jr., 15 votes.

Tellers—Messrs. Frank C. Osborn and James Ritchie, of the Civil Engineers' Club of Cleveland, Ohio.

QUESTION SUBMITTED JANUARY 11, 1901.

Ballot No. 101.

Result Announced ——.

Donate, to the Duplicate Technical Library of the University of Wisconsin, one copy of each number of the JOURNAL, of which the list shows more than fifty copies on hand.

Yes: Osborn, Harper, Brooks, Brackett, Freeman, von Geldern, Freeman, Ritchie, Tutton, Layman and Tinkham.

No: Henny.

Yes, 12; No, 1. Carried.

QUESTIONS SUBMITTED NOVEMBER 7, 1901.

Ballots Nos. 102, 103 and 104.

Results Announced December 27, 1901.

Ballot No. 102. That the Secretary be instructed to prepare an index of the material contained in the first twenty-five volumes of the JOURNAL of the Association, ending with December, 1900, and to have said index printed, bound in paper and distributed to the members of our Societies and to our subscribers, exchanges and advertisers, and that the Secretary be authorized to make such arrangements as he can for the procuring of advertisements in such index, in order to cover all or a part of the cost.

Moved by Mr. S. E. Tinkham, of the Boston Society of Civil Engineers.

Yes, 17. Carried.

Ballot No. 103. That the Secretary be authorized to furnish, to the author of any paper, at 15 cents each, additional copies of the issue of the JOURNAL containing such paper, provided due notice be given in advance, stating the number of such extra copies required.

Moved by Mr. S. E. Tinkham, of the Boston Society of Civil Engineers.

Yes, 17. Carried.

Ballot No. 104. That, from and after January 1, 1902, the Secretary shall receive, in each year, as salary, 75 cents for each member of the societies forming the Association at the close of the preceding year.

Moved by Mr. Charles H. Tutton, of the Engineers' Society of Western New York.

Yes, 10; No, 7. Lost, for want of two-thirds vote, required by Articles of Association.

QUESTION SUBMITTED NOVEMBER 7, 1901.

Result Announced January 9, 1902.

Election of officers for 1902-1903:

For Chairman—James Ritchie, Civil Engineers' Club of Cleveland, 11 votes.

Gardner S. Williams, Detroit Engineering Society, 3 votes.

A. O. Powell, Civil Engineers' Society of St. Paul, 1 vote.

For Secretary—John C. Trautwine, Jr., 15 votes.

Tellers—Messrs. W. A. Layman and S. E. Freeman (?) of the Engineers' Club of St. Louis.

QUESTION SUBMITTED NOVEMBER 23, 1901.

Ballot No. 105.

Result Announced January 4, 1902.

Authorize the Secretary to donate, to the Department of Mining and Metallurgy, McGill University, Montreal, one copy of each number of the JOURNAL, of which the list shows more than fifty copies on hand.

Yes: Tinkham, Freeman (John R.), Manley, Brooks, Brackett, Hopkinson, Ritchie, Hoag, Harper, Layman, Freeman (S. E.), Wilson, Henny, von Geldern and Malochee.

No: Tutton.

Yes, 15; No, 1. Carried.

QUESTION SUBMITTED SEPTEMBER 18, 1903.

Result Announced November 9, 1903.

Election of officers for 1904-1905:

Nominations:

For Chairman—Dexter Brackett, of the Boson Society of Civil Engineers.

For Secretary—John C. Trautwine, Jr.

The vote:

For Chairman—Mr. Brackett received 13 votes.

For Secretary—Mr. Trautwine received 14 votes.

Tellers—Messrs. Dexter Brackett and Dwight Porter, of the Boston Society of Civil Engineers.

Mr. Brackett having been nominated for the Chairmanship after accepting the appointment as teller, asked Mr. Porter to act for him.

QUESTION SUBMITTED DECEMBER 31, 1903.

Result Announced January 11, 1904.

Admission of the Toledo Society of Engineers to membership in the Association of Engineering Societies.

Yes: von Geldern, Porter, Williams, Freeman, Benjamin, Brackett, Hoffmann, Redfield, Wilson, Tinkham, Théard, Bausch, Haven, Henny, Manley, Toensfeldt and Barker.

Yes, 17. Carried.

RULINGS, ETC., BY CHAIRMEN.

November 24, 1894. J. B. Johnson. Societies which enter must require all their members to take the JOURNAL.

November 28, 1894. J. B. Johnson. Allowing the Association of Engineers of Virginia to subscribe for less than its full membership. (Reconsideration of ruling of November 24th.)

December 5, 1898. George D. Shepardson. Authorizing the publication, in the JOURNAL, of lists of members of the several Societies, with their occupations and addresses.

December 16, 1899. George D. Shepardson. Providing for a periodical audit of the accounts of the Secretary.

February 20, 1901. James Ritchie. Approving the action of the Secretary in agreeing, with *Engineering Magazine*, to maintain the price of Vol. I of the Descriptive Index at $5 per copy, with a special price of $4 to members of the Societies in the Association.

June 14, 1901. James Ritchie. Letter of request to the Secretaries of the Societies:

DEAR SIR,—I desire to call the attention of the Secretaries of our several Societies to the matter of publication of papers in other journals or periodicals prior to their appearance in the JOURNAL of the Association.

Instances of such prior publication have recently come to my notice, and I would request that, so far as possible, the Societies give the Association the advantage of first publication of any papers submitted.

March 26, 1902. James Ritchie. Authorizing the Secretary to donate, to the State Library of New Hampshire, at the request of the Boston Society of Civil Engineers, one copy of each number of the JOURNAL, of which the list shows more than fifty copies on hand.

OFFICERS OF THE BOARD OF MANAGERS FROM ITS ORGANIZATION, IN 1881, TO DECEMBER 31, 1903.

CHAIRMEN.	SOCIETIES.	FIRST ELECTED.
Benezette Williams.	Western Society of Engineers.	June 11, 1881.
J. B. Johnson.	Engineers' Club of St. Louis.	Nov. 1, 1903.
S. E. Tinkham.	Boston Society of Civil Engineers.	Nov. 11, 1895.
George D. Shepardson.	Civil Engineers' Society of St. Paul.	Nov. 11, 1897.
James Ritchie.	Civil Engineers' Club of Cleveland.	Jan. 3, 1900.
Dexter Brackett.	Boston Society of Civil Engineers.	Nov. 9, 1903.

SECRETARIES.	SOCIETIES.	FIRST ELECTED.
Henry G. Prout.	....	Between June 11 and Nov. 1, 1881.
John W. Weston.	Western Society of Engineers.	Dec. 4, 1889.
John C. Trautwine, Jr.	....	Nov. 1, 1893.

Annual Report of the Chairman of the Board of Managers.

CLEVELAND, OHIO, December 31, 1903.

To the Board of Managers of the Association of Engineering Societies.

GENTLEMEN:—I have the honor to present to you my report for the year 1903, and to transmit therewith the report of the Secretary for the same period.

The latter document shows not only an increase in the cost of the JOURNAL, due to continued advances in the printers' rates, but also a decrease in the amount of matter published.

For the former state of affairs there is probably no remedy in sight while business continues fairly active; but it is much to be hoped that the members of our Societies will see the propriety of taking advantage of the excellent facilities, presented by our JOURNAL, for the wide circulation of their papers, in excellent shape, and before an appreciative and extended circle of readers.

We have recently been gratified to receive an application for membership in the Association of Engineering Societies from the Toledo Society of Engineers, and this application is now being sent to you for letter ballot.

I desire to call attention of the members to the statement of assets and liabilities, showing a very satisfactory condition of the Association. We certainly have good reason to be well satisfied with the careful and painstaking manner in which the Secretary has handled the affairs of the Association, and I trust that the Association will this year show its appreciation of his care by allowing him a proper recompense for his services. The entire responsibility for the affairs of the Association rests upon him, and the nominal compensation which he receives is not by any means adequate.

I desire to extend to the new Chairman my best wishes for his success in the administration of his office, and I trust that he will have the same pleasant relations with the Secretary and the members as I have had in the past.

In conclusion, I wish to thank the members and the Secretary for their uniform courtesy to me during the past and to request the same for my successor.

With best wishes for the success of the Association and its members,

Very respectfully,

JAMES RITCHIE, *Chairman.*

Annual Report of the Secretary of the Board of Managers.

PHILADELPHIA, December 31, 1903.

Mr. James Ritchie, Chairman,

413 Chamber of Commerce, Cleveland, Ohio.

DEAR SIR:—I have the honor to present the following report upon the operations of the Secretary's office during the year 1903, and of the condition of the affairs of the Association at the present time.

These data are concisely stated in the following statistical appendixes:

A. Statement of receipts and expenditures during 1903.

B. Estimate of assets and liabilities at the close of 1903.

C. Detailed statement of cost of JOURNAL during 1903, by months.

D. Net cost of JOURNAL during 1903.

E. Statement of material in JOURNAL during 1903, by pages.

F. Comparison of mailing lists of the JOURNAL at the close of 1902 and of 1903, respectively.

G. Comparison of conditions, 1894 to 1903, inclusive.

H. Comparison of conditions, 1901, 1902, 1903.

J. Abstract of minutes of Board of Managers.

Repeated and sharp advances in printers' rates have brought about an increase in all the columns of Appendix H which refer to the cost of the JOURNAL. Notwithstanding this, our cash balance and our estimated net assets, at the close of 1903, are but slightly less than at the close of 1902, although the annual assessment of $2 per member, established in 1898, has been maintained. This is the lowest rate of assessment thus far reached, except that, in 1899, the surplus in the treasury permitted a special rebate of $1 per member, bringing the actual net assessment, for that year, to $1 per member.

I call your attention especially to the marked and gratifying extent to which some of the Societies have taken advantage of the arrangement whereby the Association allows, to its Societies, a commission of 90 per cent. upon all advertisements obtained by them for the Association JOURNAL, thus practically printing the advertisements for the Societies at cost, and leaving, to the Societies, the net receipts from their insertion.

The Engineers' Society of Western New York earns, in this way, an amount practically equal to its annual assessments, and the Boston Society has greatly increased its activity in this direction during the year just closed.

Thus far, however, only a beginning has been made in this direction; and our JOURNAL still remains far from earning, in this way, the sums to which its value, as an advertising medium, entitles it.

The exchange of advertisements, between the JOURNAL and a number of the best engineering periodicals, has been continued.

During the year 1903, thirty-four papers, as follows, were published in the Association JOURNAL:

BOSTON SOCIETY OF CIVIL ENGINEERS.

"Foundation for Coal Pocket at Lincoln Wharf, Boston Elevated Railway Company," by Robert B. Davis. March.

"A Comparison of Three Methods of Estimating Quantities of Soil Stripping from Water-Supply Reservoirs," by Frank S. Hart. April.

"Method of Estimating Quantities of Soil Excavation from Wachusett Reservoir," by Chas. A. Bowman. April.

"Boston Foundations," by Joseph R. Worcester. June.

"Foundations," by George B. Francis. June.

"The Failure of a Sea Wall and Its Reconstruction," by Clarence T. Fernald. June.

"Foundations for the Elevated Structure of the Boston Elevated Railway," by George A. Kimball. June.

"Early and Curious Types of the Cantilever Bridge in New England and New Brunswick," by Alfred W. Parker. July.

"Action of Sea Worms on Foundations in Boston Harbor," by F. W. Hodgdon. August.

"Rainfall and Run-off of New England, Atlantic Coast and Southwestern Colorado Streams," by William O. Webber. November.

Civil Engineers' Club of Cleveland.

"Electric Railway Bridges," by Wilbur J. Watson. January.

"The Burning of Pulverized Coal," by C. O. Bartlett. July.

"The Cost of Open-Hearth Steel as Affected by Using Blast-Furnace Gas in Gas Engines, and Remarks on the Latest Improvements," by Peter Eyermann. September.

Engineers' Club of Minneapolis.

"The Theory of Operation of the Gasoline Engine," by E. C. Oliver. February.

"Red River Valley Drainage Ditches," by Prof. W. R. Hoag. April.

Montana Society of Engineers.

"Annual Address," by Joseph H. Harper. May.

Engineers' Club of St. Louis.

"Electric Shop Drive." Discussion. January.

"On the Use of Beaumont Oil as Fuel," by Henry H. Humphrey. March.

"St. Louis Water Supply," by R. E. McMath. May.

"A Century's Progress in Engineering Education in the United States," by Robert Heywood Fernald. July.

"Reduction of Grade on Railroads," by C. D. Purdon. July.

"The Heyland Induction Motor," by A. S. Langsdorf. September.

"The Physical Structure of Metals and Alloys," by J. J. Kessler, Jr. December.

Technical Society of the Pacific Coast.

"Rainfall on the Pacific Coast of North and South America and the Factors of Water Supply in California," by Marsden Manson. March.

"Personal Experiences in the Construction of a Landing Pier for the Ocos Railway, Guatemala, Central America," by Charles List. March.

"Concrete-Metal Construction," by Emile Villet. October.

"Patent Laws. Are They any Longer Necessary to Progress in Mechanic Arts?" by Geo. W. Dickie. December.

"Patent Law Administration," by John Richards. December.

Detroit Engineering Society.

"Detroit Sewer System," by W. C. King. January.

ENGINEERS' SOCIETY OF WESTERN NEW YORK.

"Abatement of the Smoke Nuisance." Report of Smoke-Abatement Committee. January.

"The Metric System," by C. H. Tutton. February.

"Good Roads," by George C. Diehl. October.

LOUISIANA ENGINEERING SOCIETY.

"Goldschmidt Method of Metallurgy and High Temperature Production by Means of Thermite," by B. Palmer Caldwell. August.

"Gas," by Thomas D. Miller. October.

The abstract of minutes of the Board of Managers, including the original meeting of representatives of the Societies, held in Chicago, December 4, 1880, and extending to the present date inclusive, and the digest of Rules, following the Articles of Association, have been compiled from such data as are available to the Secretary, and it is hardly to be hoped that they are complete. Indeed, certain gaps are indicated in the record. The undersigned will be greatly obliged for any suggestions looking to the improvement of these records.

Respectfully submitted,

JOHN C. TRAUTWINE, JR., *Secretary.*

APPENDIX A.

Statement of Receipts and Expenditures during 1903.

CASH, 1903.

Dr.

To Cash Balance, January 1, 1903		$1,608.68	
" Assessments, at $2.00 per member:			
Boston Society of Civil Engineers	$1,030.50		
Civil Engineers' Club of Cleveland	569.00		
Engineers' Club of St. Louis	339.50		
Civil Engineers' Society of St. Paul	60.00		
Engineers' Club of Minneapolis	186.50		
Montana Society of Engineers	241.00		
Technical Society of the Pacific Coast	301.00		
Detroit Engineering Society	161.00		
Engineers' Society of Western New York	93.50		
Louisiana Engineering Society	125.00		
		3,107.00	
To Initiation Fee, Toledo Society of Engineers		27.00	
" Subscriptions		641.56	
" Sales of JOURNAL		157.62	
" " " Descriptive Index		20.00	
" " " Reprints		44.25	
" " " Periodicals		16.60	
" Advertisements		377.00	
" Advance proofs of paper, etc.		10.00	
" Interest on deposits		43.82	
			$6,053.53

Cr.

By Patterson & White Co. (Printers)		$2,875.94	
" Illustrations		680.24	
" Secretary's salary		600.00	
" Commissions on subscriptions		33.00	
" " " sales		19.95	
" " " advertisements:			
Boston Society of Civil Engineers	$216.00		
Civil Engineers' Club of Cleveland	16.20		
Engineers' Club of St. Louis	36.00		
		268.20	
" Telephone service, two years		20.00	
" Binding Volumes XXVIII and XXIX		2.00	
" Messenger service		2.24	
" Telegrams		6.14	
" Express charges		3.43	
" Postage stamps		34.55	
" Stationery		10.58	
" Mimeographing		1.65	
			$4,557.92
" Cash Balance, December 31, 1903:			
Provident Life and Trust Co.	$1,475.47		
Cash on hand	20.14		
			1,495.61
			$6,053.53

APPENDIX B.

Estimate of Assets and Liabilities at the Close of 1903.

AVAILABLE ASSETS.

Cash Balance, December 31, 1903		$1,495.61	
Less subscriptions for 1904, paid during 1903		63.00	
			$1,432.61
Amounts receivable from Societies (for assessments, advertisements, etc.):			
Boston Society of Civil Engineers	$489.00		
Civil Engineers' Club of Cleveland	158.40		
Engineers' Club of St. Louis	152.50		
Civil Engineers' Society of St. Paul	10.50		
Montana Society of Engineers	61.25		
Technical Society of the Pacific Coast	3.50		
Detroit Engineering Society	57.50		
Engineers' Society of Western New York	273.00		
Louisiana Engineering Society	34.50		
		$1,240.15	
Subscriptions due:			
For 1903	$75.00		
" 1902	12.00		
" 1901 and earlier	219.00		
		306.00	
For reprints		122.92	
" advertisements (other than through Societies)		371.33	
" sales of Journal		23.05	
			2,063.45
			$3,496.06

LIABILITIES.

Patterson & White Co. (Printers):			
For December Journal	$221.99		
" reprints	46.58		
		$268.57	
Commissions on advertisements:			
Boston Society of Civil Engineers	$440.10		
Civil Engineers' Club of Cleveland	61.20		
Engineers' Club of St. Louis	36.00		
Engineers' Society of Western New York	176.40		
A. E. Story, advertising agent	25.00		
		738.70	
Illustrations		12.25	
			1,019.52
Net assets			$2,476.54

APPENDIX C.

Detailed Statement of Gross Cost of Journal during 1903, by Months.

	1	2	3	4	5	6	7	8	9	10	11	12	13
	Composition.	Paper, Presswork, Binding.	Wrapping, etc	Postage.	Printer, Sum of 1, 2, 3 and 4.	Illustrations.*	Cost of Manufact'e Sum of 1, 2, 6.	Wrappers.	Sec'y's Salary.	Sundries.†	Total. Sum of 5, 6, 8, 9, 10.	No. of Pages.‡	Cost per Page.‡
January	$249 70	$221 25	$8 42	$17 16	$496 53	$38 25	$509 20	$4 75	$50 00	$28 28	$617 81	182	$3 39
February	45 23	66 25	4 35	6 61	122 44	6 60	118 08	4 75	50 00	12 23	196 02	60	3 27
March	67 55	105 00	7 62	10 43	190 60	146 76	319 31	4 75	50 00	7 25	399 36	80	4 99
April	59 53	98 90	5 09	8 50	172 02	58 28	216 71	4 75	50 00	31 98	317 03	74	4 28
May	104 85	148 25	6 07	14 04	273 21	3 36	256 46	4 75	50 00	8 15	339 47	118	2 88
June	105 84	150 14	4 40	14 66	275 04	288 26	544 24	4 96	50 00	9 20	627 46	118	5 32
July	68 75	78 40	4 38	8 36	159 89	70 90	218 05	4 75	50 00	6 18	291 72	70	4 17
August	21 40	47 75	4 91	5 39	79 45	50 88	120 03	4 75	50 00	11 03	196 11	36	5 45
September	36 21	76 75	5 81	5 67	124 44	33 58	146 54	4 75	50 00	3 45	216 22	48	4 55
October	67 61	99 75	4 81	8 01	180 18	36 75	204 11	4 75	50 00	7 94	279 62	70	3 99
November	138 63	112 75	5 33	8 20	264 91	15 10	266 48	4 75	50 00	2 87	337 63	78	4 33
December	80 84	110 00	5 68	8 22	204 74	24 75	215 59	4 75	50 00	30 55	314 79	72	4 55
Totals and averages	$1,046 14	$1,315 19	$66 87	$115 25	$2,543 45	$773 47	$3,134 80	$57 21	$600 00	$159 11	$4,133 24	1,006	$4 11

* The figures in column 6 (Illustrations) include preparation of cuts and lithographic stones, and paper and presswork on insets.

† The figures in column 10 (Sundries) include all expenditures of the Association (such as stationery, postage, circulars, etc.) chargeable to the Journal and not embraced in any other column. They do not include the cost of preparing reprints of papers.

‡ The figures in columns 12 (No. of Pages) and 13 (Cost per Page) include 4 cover pages in each number, and 16 pages in indexes to Vols. XXX and XXXI.

APPENDIX D.

NET COST OF JOURNAL, 1903.

Gross cost, as per Appendix C			$4,133.24
Paid for reprints		*$92.04	
Received from sales of reprints		44.25	
			†47.79
			$4,181.03
Deduct receipts, as below, as per Appendix A:			
From subscriptions	$641.56		
Less commissions	33.00		
		$608.56	
From sales of JOURNALS	$157.62		
" " " Descriptive Index	20.00		
	$177.62		
Less commissions	19.95		
		157.67	
From sales of periodicals		16.60	
" advertisements	$377.00		
Less commissions	268.20		
		108.80	
From interest on deposits		43.82	
			935.45
Net cost of JOURNAL, 1903			$3,245.58

APPENDIX E.

STATEMENT OF MATERIAL IN JOURNAL DURING 1903, BY PAGES.

	Papers.	Proceedings.	Chairman's Report, etc.	Advertisements.	Indexes to Vols.	List of Members.	Totals.	Cuts.	Plates and Full-Page Cuts.
January	46	14	14	17	. .	87	178	6	2
February	34	6	. .	16	. .	. .	56	5	. .
March	44	16	. .	16	. .	. .	76	18	7
April	52	2	. .	16	. .	. .	70	8	6
May	94	4	. .	16	. .	. .	114	5	. .
June	82	8	. .	16	8	. .	114	6	26
July	48	2	. .	16	. .	. .	66	5	7
August	14	2	. .	16	. .	. .	32	2	5
September	26	2	. .	16	. .	. .	44	8	1
October	42	6	. .	18	. .	. .	66	6	7
November	54	2	. .	18	. .	. .	74	1	1
December	32	10	. .	18	8	. .	68	8	1
Totals	568	74	14	199	16	87	958	78	63
Covers							48		
Total.							1006		

*Compiled from printers' bills for 1903.

†Several considerable bills for reprints remaining due the Association at the close of 1903, the payments on that account, during 1903, have exceeded the receipts during the same period.

APPENDIX F.

Comparison of the mailing lists of the JOURNAL, at the close of 1902 and 1903, respectively:

	1902.	1903.	Increase.	Decrease.
Boston Society of Civil Engineers	513	520	7	..
Civil Engineers' Club of Cleveland	233	216	..	17
Engineers' Club of St. Louis	215	225	10	..
Civil Engineers' Society of St. Paul	25	21	..	4
Engineers' Club of Minneapolis	61	86	25	..
Montana Society of Engineers	118	109	..	9
Technical Society of the Pacific Coast	150	154	4	..
Detroit Engineering Society	106	122	16	..
Engineers' Society of Western New York	65	68	3	..
Louisiana Engineering Society	58	67	9	..
In the Societies composing the Association	1544	1588	74	30
Net Increase	**44**			
Extra copies to Societies	52	41	..	11
Advertisers	20	34	14	..
Exchanges	133	131	..	2
Subscribers	220	222	2	..
Complimentary copies	1	..	..	..
	1970	2016	90	43

Besides this, many copies have been sold and specimen pages sent out, and authors of papers have each received five copies of the JOURNAL containing them. In all, 2300 copies of the May number were printed, 2350 of June and 2250 of each of the other months.

APPENDIX G.

Comparison of Conditions, 1894 to 1903, Inclusive.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
							Pages of Papers.		Gross Cost of Journal.*					Illustrations.			
Year.	Number of Societies in Association, Dec. 31.	Number of Names on Mail Lists of Societies, Dec. 31.	Subscribers, Dec. 31.	Exchanges, Dec. 31.	Net Receipts from Advertisements.	Total Number of Pages in Journal.	Total.	Per 1000 Members on Mail List.	Total.	Per Page.	Per Member.	Per Member per 1000 Pages.	Annual Assessment per Member.	Small Cuts.	Plates and Full-Page Cuts.	Cost.	Net Assets, Dec. 31.
1894	8	1174	170	110	$671 00	1290	653	556	$5774 59	$4 48	$4 92	$3 81	$3 00	86	54	$651 60	—$758 91‡
1895	11	1477	215	122	599 09	1482	792	536	5911 48	3 99	4 00	2 70	3 66	116	66	859 60	223 93
1896	9	1106	241	108	763 25	856	490	443	3928 42	4 59	3 55	4 15	3 00	62	56	771 39	1244 94
1897	10	1252	233	102	410 25	1016	638	510	3140 43	3 09	2 51	2 47	2 50	57	45	503 85	2562 04
1898	12	1370	246	114	465 58	1110	738	539	3462 08	3 12	2 53	2 28	2 00	166	42	729 38	2936 71
1899	11	1475	249	115	390 88	958	544	369	3233 44	3 38	2 19	2 29	2 00†	124	30	561 24	2442 70†
1900	11	1541	216	116	370 83	1130	666	432	4351 53	3 85	2 82	2 50	2 00	112	27	590 82	2162 67
1901	11	1597	224	115	244 10§	1074	646	405	4856 64	4 52	3 04	2 83	2 00	213	55	1160 90	2062 72
1902	11	1544	220	135	260 60	1030	610	395	3927 01	3 81	2 54	2 36	2 00	172	20	442 43	2601 19
1903	10	1588	222	131	108 80	1006	568	358	4133 24	4 11	2 60	2 58	2 00	78	63	773 47	2476 54

* The publication of the Descriptive Index of Current Technical Literature was discontinued at the end of 1895.

† During 1899, with an assessment of $2.00 per member, the Association made a rebate of $1.00 per member for the purpose of reducing surplus, making the actual charge only $1.00 per member, and reducing the assessment by about $1400.

‡ Deficit at close of 1894. Since then, each year has shown a surplus.

§ In Appendix F, for 1894–1901, as printed in the Journal for January, 1902, the gross receipts, $331.50, were given, by oversight, instead of the net receipts, $244.10.

APPENDIX H.

COMPARISON OF CONDITIONS, 1901, 1902, 1903.

December 31st.	1	2	3	4	5	6				7				8
	Members on Mail List.	Total Pages in JOURNAL.	Printers' Bills.	Cost of Illustrations.	Cost of Manufacture.	Gross Cost of JOURNAL.				Net Cost of JOURNAL.				Net Assets.
						a	b	c	d	a	b	c	d	
						Total.	Per Page.	PerMember.	Per Member per 1000 Pages.	Total.	Per Page.	Per Member.	Per Member per 1000 Pages.	
	App. G, Col. 2.	App. G, Col. 6.	App. C, Col. 5.	App. G, Col. 16.	App. C, Col. 7.	App. G, Col. 9.	App. G, Col. 10.	App. G, Col. 11.	App. G, Col. 12.	App. D.				App. G, Col. 17.
1901	1597	1074	$2734.74	$1160.90	$3599.01	$4856.64	$4.52	$3.04	$2.83	$3311.60*	$3.08	$2.07	$1.92	$2062.72
Increase	......	......	......	......	......	......	......	......	......	......	......	......	......	$538.47
Decrease	53	44	$97.61	$718 47	$689.72	$927.63	$0.71	$0.50	$0.47	$723.02	$0.57	$0.39	$0.29	......
Per Cent.	3.3	4.1	3.6	62	19	39	16	16	17	22	17	19	15	21
1902	1544	1030	$2637.13	$442.43	$2909.29	$3927.01	$3.81	$2.54	$2.36	$2588.58	$2.51	$1.68	$1.63	$2601.19
Increase	44	......	......	$331.04	$225.51	$206.23	$0.30	$0.06	$0.22	$657.00	$0.72	$0.36	$0.37	......
Decrease	......	24	$93.68	......	......	......	......	......	......	......	......	......	......	$124.65
Per Cent.	2.8	2.3	3.6	7.5	7.8	5.3	7.9	2.4	9 3	25.4	28.7	21.4	22.7	4.8
1903	1588	1006	$2543.45	$773.47	$3134.80	$4133.24	$4.11	$2.60	$2.58	$3245.58	$3.23	$2 04	$2.00	$2476.54

* See JOURNAL, Vol. XXVIII, No. 1, page 48, January, 1902.

REPORTS OF AUDITORS.

FOR 1899.

BOSTON, MASS., February 5, 1900.

The undersigned, having been requested by the retiring Chairman of the Board, Prof. George D. Shepardson, to audit the books and accounts of the Secretary for the year 1899, would report that the books have been correctly kept and in a businesslike manner, that satisfactory vouchers have been shown for the expenditures and that the balance on hand December 31st was $1866.34.

S. E. TINKHAM,
HENRY MANLEY.

FOR 1900-1901.

31 MILK STREET, BOSTON, February 8, 1904.

I have examined the accounts of the Secretary of the Board of Managers of the Association of Engineering Societies for the calendar years 1900 and 1901 and found them correctly cast and properly vouched.

FRED BROOKS.

The undersigned has made such examination of the accounts of the Secretary of the Board of Managers of the Association of Engineering Societies for the calendar years 1900-1901 as to satisfy him of their general correctness, and has also conferred with Mr. Fred Brooks, Auditor, relative to the same, and accepts and concurs in the statement that they are correctly cast and properly vouched.

JOHN R. FREEMAN.

NOTE.—Mr. Brooks's and Mr. Freeman's reports have been delayed by the fact that numerous slight discrepancies, discovered by them in their examination of the books early in 1902, have, owing to want of time, remained unexplained or unadjusted until recently.—*Secretary.*

FOR 1902-1903.

The undersigned appointed by the Chairman of the Board of Managers of the Association of Engineering Societies to examine the books and accounts of the Secretary of the Association, for the calendar years 1902 and 1903, have attended to that duty and find them correctly kept, with satisfactory vouchers for all payments and that the cash balance in his hands December 31, 1903, was $1495.61.

HENRY MANLEY,
S. E. TINKHAM.

NOTE.—The Reports of Auditors for 1900-1901 and for 1902-1903, although dated February, 1904, are printed in the JOURNAL for January, which, in accordance with our custom, goes to press in February.—*Secretary.*

Editors reprinting articles from this journal are requested to credit not only the JOURNAL, but also the Society before which such articles were read.

ASSOCIATION OF ENGINEERING SOCIETIES.

Organized 1881.

VOL. XXXII. FEBRUARY, 1904. No. 2.

TIMBER CRIB FOUNDATIONS.

BY GEORGE B. FRANCIS, MEMBER OF THE BOSTON SOCIETY OF CIVIL ENGINEERS.

[Read before the Society, January 14, 1904.*]

IN the following article the writer desires to describe his own experience in the construction of timber cribs for different purposes in various parts of the United States, and no attempt will be made to set forth all the uses for which they may be constructed, or to explain the many combinations in which the constituent parts may be arranged.

Generally speaking, a timber crib may be said to be one of the big, crude structures which engineers use for temporary work when built above water, or to save money on initial cost. When placed in water not infested with destructive worms, they are, if carefully made, structures for permanent work.

CRIB AT HALLETT'S HADES ON THE OREGON RAILWAY AND NAVIGATION COMPANY'S LINE, COLUMBIA RIVER, OREGON. BUILT IN 1883.

Fig. 1 shows Hallett's Hades, a point about twelve miles west of The Dalles, Oregon, where the railroad track passes closely along the base of a precipitous cliff, varying in height from 100 to 500 feet. This cliff was in fact blown off for the formation of the roadbed. Its rock is of volcanic formation, and of such a nature as to be displaced by the frosts and winds, in blocks from a few pounds to a few tons in weight. At times scarcely an hour would pass without pieces of large size falling and causing damage to track or passing trains. In consequence, it was necessary to keep watchmen constantly on duty, and oblige all trains to slow down

*Manuscript received January 25, 1904.—Secretary, Ass'n of Eng. Socs.

and run with caution. Instances have occurred where masses of falling rock have broken through the roof of a passenger car.

On the river side of the track the rock slope made off into the river at an angle of one to one, and at low-water stage the river was about 30 feet below the rail level.

The company decided to build a sawed-timber crib, several hundred feet in length, on this slope, so that the track might be moved from the face of the cliff about 25 feet, and placed on the crib beyond the range of falling rocks. On account of less expense it was considered preferable to build a crib than to make a fill, as the water was of great depth.

A firm base was made by casting over the lower part of the slope, and on this the timber was laid in cob-house fashion, and filled with rock. Holes were drilled in all the large boulders left beneath the crib, and the lower courses of timber were anchored to these in various ways with steel rods. At all intersections of the timber drift bolts were used. In all, several million feet board measure were put into this crib. Subsequently, some very heavy rock fell, wrecking portions of it and involving repair.

During the construction of this crib it was my duty to mark the transit lines for the location of the new track and to see that the crib was laid out correctly to fit the new conditions of alignment and grade. At one time the rodman was giving a backsight on the existing track under the highest part of the cliff when we suddenly heard the rattle of loose rock above. Looking up I saw a considerable quantity falling, directly over his head, and at once shouted to him to run; he did so (probably without waiting to hear me), and escaped about fifteen tons of material, which fell on and destroyed the backsight. These frequent falls made life hazardous for the workmen, but the work was completed without accident.

It was also a part of our duty to determine the length and amount of timber used, and each stick had to be carefully measured. On comparison with the statements of the mills, some large discrepancies were found. Investigation showed that the mills recorded the length of sticks furnished, in even figures at the nearest 2 feet, and, as the sticks averaged probably not more than 24 feet in length, a difference of 5 per cent. was not excessive. Refinement in measurement was not in vogue where timber was so plentiful and cheap. It would be interesting to know the present condition of the work, if it has not been replaced.

The photograph was taken previous to the construction of the crib. This work was built under the direction of Mr. A. A. Schenck, a Member of the American Society of Civil Engineers.

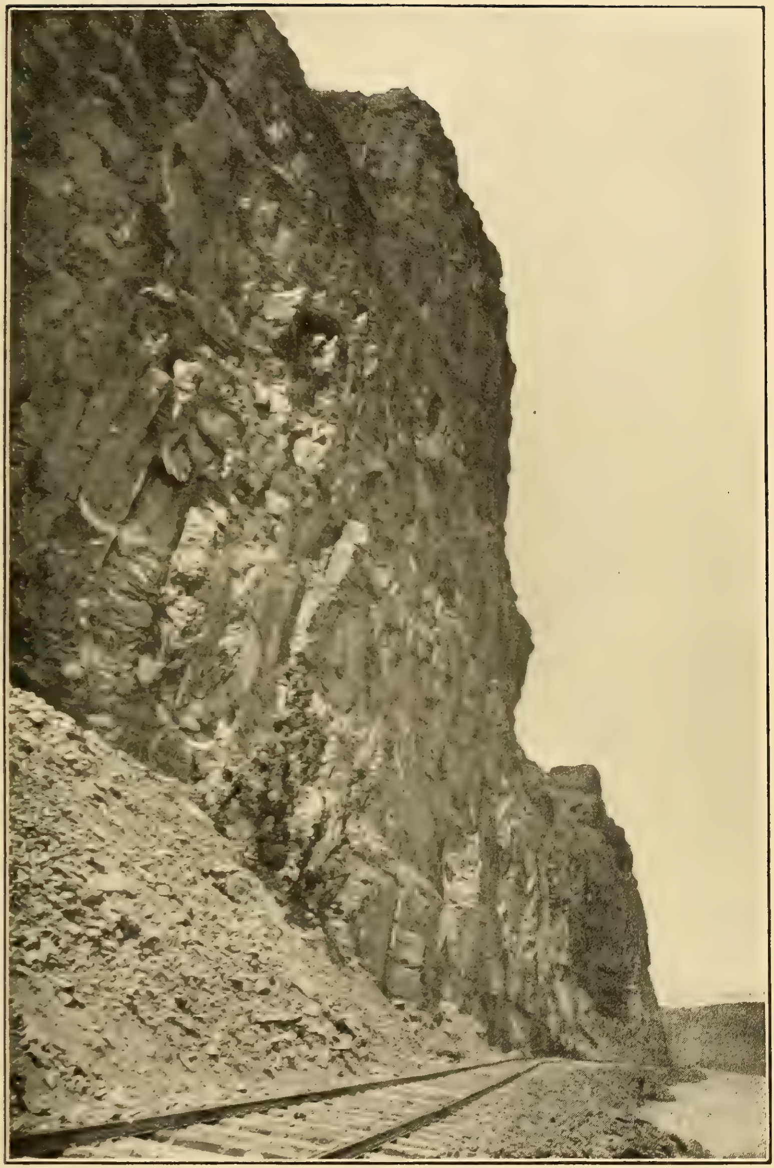


Fig. 1. Location of Crib at Hallett's Hades.

CRIB AT TONAWANDA ISLAND IN THE NIAGARA RIVER ON A BRANCH OF THE N. Y. C. & H. R. R. R. AT TONAWANDA, N. Y. BUILT IN 1886.

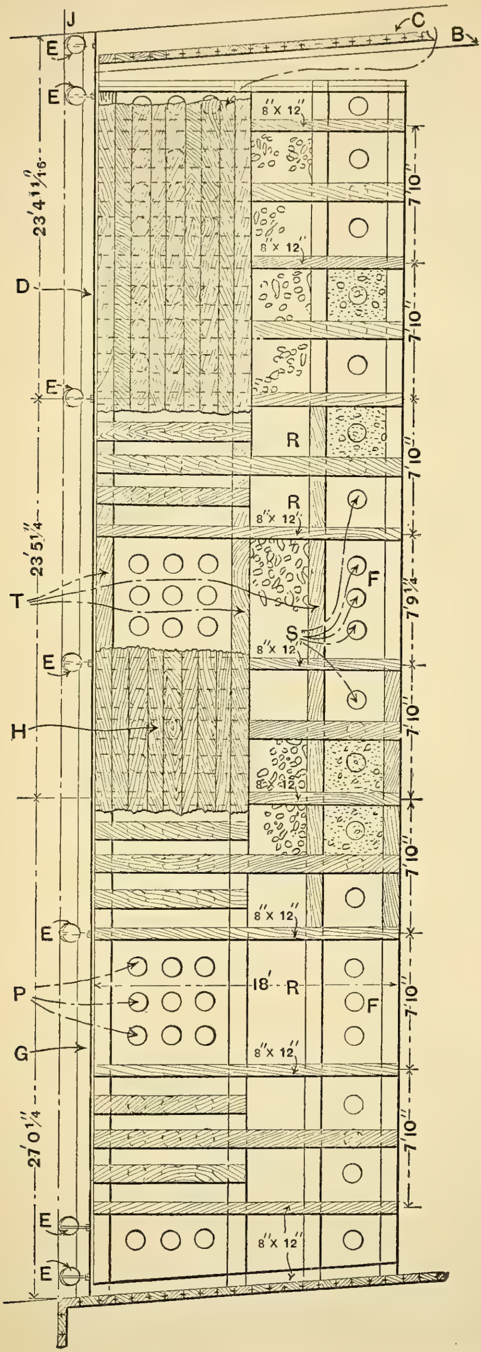
Fig. 2 illustrates the construction of one of the end piers for the drawbridge. Two of these end piers and one center pier were constructed in the manner exhibited for a single track drawbridge, in about 18 feet of fresh water, flowing at the rate of five miles an hour. As there are no worms to destroy the timber in the fresh water of the Great Lakes, this was the most economical way to construct permanent foundations for the bridge.

The cribs were built on ways, on the shore, and launched. They were then ballasted in the loading pockets, towed into position and sunk by means of additional ballast in the loading pockets. Later, piles for supporting the pier-load were driven into the open pockets, and the riprap, concrete and masonry work followed. In this construction all the timber was sized and framed together. The corner timbers being half-lapped and the cross partition timbers half-lapped and framed on a miter. It was quite a difficult matter to tow the cribs into position, on account of the strong current, and at the first trial, owing to an insufficient number of tugs, the larger crib became unmanageable. It was, however, towed to the shore, some few hundred feet below the site of the bridge, and afterward brought into position. It will be noticed on the cut that above the sixth course of timber the only method of fastening the courses one to another is by means of drift bolts put in at an angle. This work was completed in a thorough manner, at a moderate cost, as compared with masonry piers carried to the bed of the stream, and the bridge is still doing good service.

A DESIGN FOR A CRIB BASE FOR A SEA WALL FOR THE FORE RIVER SHIP AND ENGINE WORKS, AT QUINCY, MASS., IN 1901.

This design (Fig. 3) was made and submitted with a contractor's bid. The work of construction was not awarded to any bidder, but I understand that a crib based on a similar design has been adopted by the owners for this location. The scheme was to secure a wharf front, about 900 feet long, giving 30 feet of water at low tide, and to operate a heavy Gantry crane along the same.

The underlying material is of sand, and it was proposed to dredge this out and sink the crib; then to drive piling to support the wall and crane track in a firm manner. The piles were to be driven in the open pockets, and the loading for sinking the crib was to be placed in the closed pockets. It was intended that the crib be started in sections about 100 feet long on the ways on shore, then launched and completed in the water. As there are sea worms



B. Line of superstructure wall.

C. Sheet piling of cofferdam, cut off to allow plank platform to cantilever to property line.

D. 10 x 14-inch waling strips.

E. Buffer piles.

F. Filling pocket.

H. Platform under sea wall.

J. Harbor line.

P. Bearing piles.

R. Loading pocket.

S. Brace piles.

T. Stringers.

FIG. 4. PLAN OF CRIB AT PROVIDENCE, R. I.

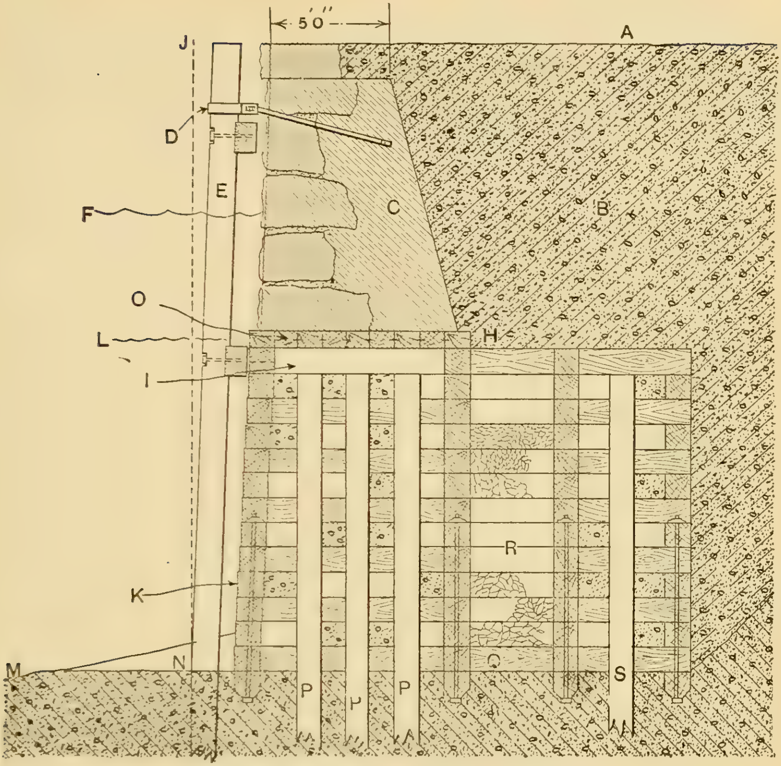


FIG. 5. CROSS SECTION THROUGH CRIB AT PROVIDENCE, R. I.

A. Approximate finished grade. El. 7.00.
B. Solid fill.
C. Portland cement concrete.
D. 4 x ⅝-inch wrought-iron collars and 2½ x ⅝-inch wrought-iron anchor bars for buffer piles.
E. Buffer piles.
F. High water.
H. Platform.
I. 12 x 12-inch pile caps.
J. Harbor line.
K. Longitudinal partitions, bolted together with long 1¼-inch tie bolts.
L. Low water. El.—5.00.
M. Present river bed.
N. Dredge line. El—18.50.
P. Foundation piles.
Q. Floor of loading pocket.
R. Loading pocket.
S. Brace piles.

in this water, it was proposed to cover the face of the crib with creasoted timber, 4 inches in thickness. Such a wharf front, including dredging and wall, could be built for very much less outlay than wall laid under water, as all of the work could be done without the aid of a diver and in a rapid manner, and at the same time would be equally permanent and substantial.

CRIB AT PROVIDENCE, R. I., FOR BASE OF SEA WALL AT THE MANCHESTER STREET POWER HOUSE OF THE RHODE ISLAND SUBURBAN RAILWAY COMPANY. BUILT IN 1902.

The conditions (Figs. 4, 5 and 6) here were similar to those at Quincy, Mass., excepting that the bottom of the channel is a

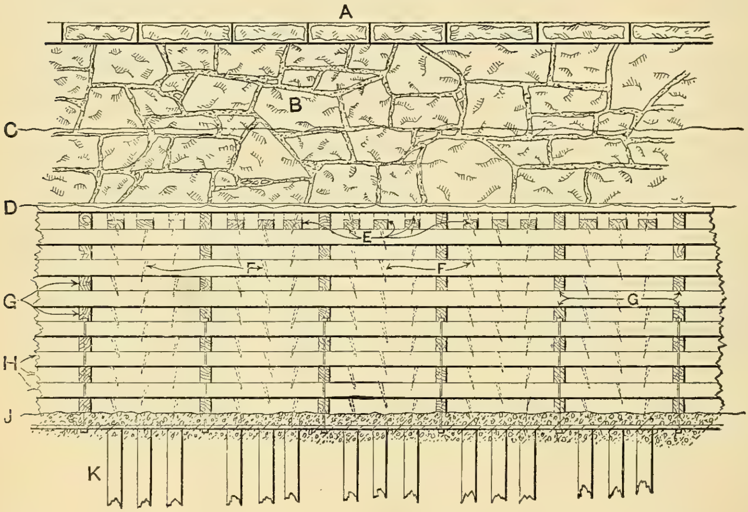


FIG. 6. ELEVATION OF CRIB AT PROVIDENCE, R. I.

A. Approximate finished grade. El. 7.00.
B. Granite-face masonry.
C. High water.
D. Low water. El.—5.00.
E. Pile caps.
F. ⅞ x 18-inch drift pins.
G. Ties, 8 x 12 inches, continuous.
H. Timbers, 12 x 12 inches.
J. Dredge line. El.—18.50.
K. Wall foundation piles.

soft river mud. The same principles were adopted, with the exception of a creasoted face planking. There are practically no worms in the upper harbor at Providence, owing to the foulness of the water. In this case the crib was built and sunk without the use of

a diver. The sea wall was built on the bearing piles driven in the open pockets.

For a sea wall against which vessels are to lie, such a crib offers a most substantial base. It is thus possible to obtain a permanent structure, built of ordinary materials, put together by inexpensive labor, above water, and, above all, at a reasonable cost.

The addition of bearing piles in the open pockets secures a firm foundation for any structure that may be needed close to the wharf front.

CRIB AT WILKESBARRE, PA., ALONG THE SUSQUEHANNA RIVER, FOR THE CENTRAL VALLEY RAILROAD COMPANY. BUILT IN 1903.

The Susquehanna River at this point has a rise and fall of about 30 feet. Owing to the other railroads having, in a large degree, pre-empted the river bank, it was necessary to locate the new double-track railroad well out toward the low-water line, save

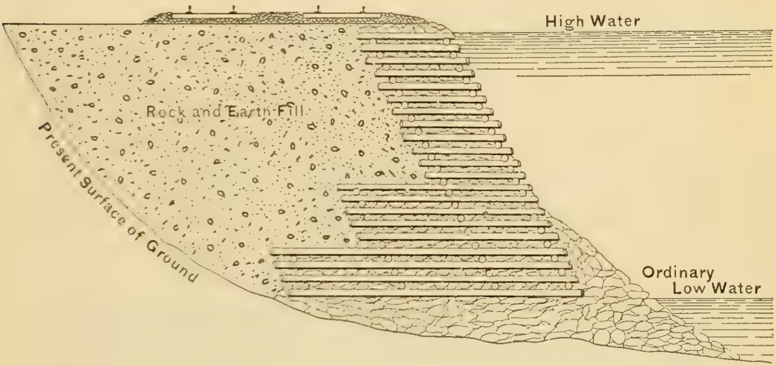


FIG. 7. TYPICAL CROSS SECTION OF CRIB, SUSQUEHANNA RIVER.

NOTE.—Transverse timbers spaced 7 feet cen to cen. Drift bolt, ⅞-inch at each intersection. Longitudinal timbers sized to make courses level. Joints of longitudinal timbers half-lapped and drift-bolted.

at certain rocky points. The construction of a plain embankment at these places involved two undesirable features: first, a slope, extending too far out into the river, and in a manner liable to meet with objections; second, the necessity of securing a large amount of material, not readily available at low cost, until the completion of the road.

A timber trestle was out of the question, as it would have to stand in the water at flood height, while heavy ice was running in the river. A masonry wall was very expensive, and its foundations somewhat uncertain.

It was finally decided to construct three round-timber cribs

(Figs. 7, 8, 9, 10 and 11), each about 600 feet long, and with maximum heights of about 30 feet. The bases are founded either on shelves cut into the river bank, or on riprap dumped into the river to above the low-water mark. The pockets are 7 feet square, and are filled with riprap. The round logs are drift, bolted at each intersection. Hemlock, spruce, pine and some hard woods have been used. It was difficult to obtain the large quantities at the proper times, and some of it had to be brought from as far away as Virginia. It was also troublesome to obtain suitable stone for the riprap. Here, again, it was necessary to go considerable distances for material, as the rock available in the immediate vicinity is an inferior anthracite mine rock, called "gob," which disintegrates upon exposure to weather.

In this work reduction of first cost was the great consideration.

CRIBS FOR CENTER AND END PIERS OF A DRAWBRIDGE AT GRAND HAVEN, MICH. BUILT IN 1903 FOR THE GRAND RAPIDS, GRAND HAVEN AND MUSKEGON RAILROAD.

In this case it was desirable to build permanent substructures at the least cost. In this fresh water there were no worms, consequently a substantial timber structure below water level would be as durable as masonry.

The work involved the removal of an old swinging highway drawbridge on simple piling, and building a new and wider drawbridge to accommodate the highway traffic and an interurban electric railroad.

This widening of structure made a new center line of bridge, and additional piles were driven, which, together with the old ones, took the new load. Around the entire piling, at each pier, cribs were built on the surface of the water, and were finally sunk, by means of stone in special loading pockets, to the required depth. They were then filled in an surrounded with riprap, to give them great stiffness. The piles, which were to support the new load, were then capped, and concrete structures carried from low water to the required height for bridge bearings. This construction gave permanent piers at low cost.

Fig. 12 shows the methods used on the center pier. The crib work was designed in New York City, under the author's direction, and executed under the direction of others at the site of the work.

IN GENERAL.

The use of rough timber cribs for cofferdam purposes is quite common. They form a substantial bulkhead, against which light sheathing can be successfully placed, even in streams where it is

Fig. 8. Crib, Susquehanna River.

Fig. 9. Crib, Susquehanna River.

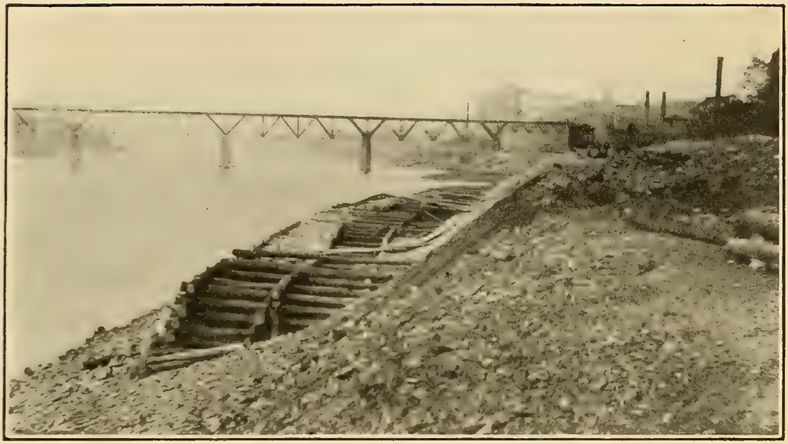


Fig. 10. Crib, Susquehanna River.

Fig. 11. Crib, Susquehanna River.

impossible to drive sheathing in the ordinary manner. But such use is, of course, temporary.

In the early days in the Eastern States (and even now in the frontier region) timber cribs were made use of for highway bridge piers. The writer saw a number of such instances this summer in Yellowstone Park, where the Government engineers had quickly and cheaply made substantial crib piers capable of lasting a dozen years or more.

A great many "cob-house" or crib docks, forty or fifty years old, were removed from the site of the South Terminal Station, in Boston, in 1897-98.

In the mud flats, on the Jersey shore of the Hudson River, opposite New York City, a great many bulkheads have been made out of round log cribs, with a base from 20 to 30 feet wide, and sunk in dredged channels. The dredged material from the front was later placed in the rear.

Crib dams are cheaply constructed, and have great lasting qualities when properly loaded with rock and earth. Even a log dwelling house is a sort of crib construction, and, compared with a frame house, is quite as durable and frequently quite as artistic.

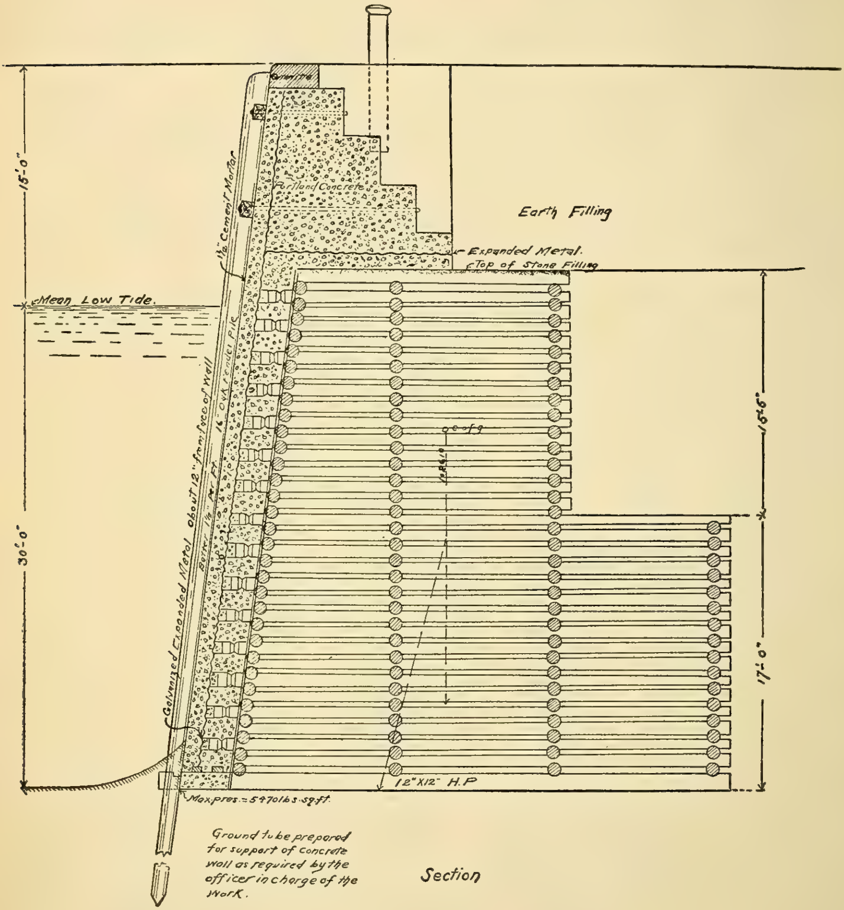
The use of crib timber in breakwaters, jetties and other marine structures, where it is covered from the attacks of worms, is very common. Timber cribs are also frequently used as curbing, sunk in dredged places around the site of large bridge piers; afterward, when buried in the riprap or gravel, they give greater breadth and stiffness to the base of the structure. Cribs of this character (Fig. 13) were sunk in the mud around the piers of the Thames River Bridge, at New London, Conn.

In this article no reference is intended to be made regarding the use of timber as "grillage," or flooring upon piling, or as platforms placed upon earth or mud to support masonry construction. There are still many uses for timber structures made in crib style, particularly where the timber is to be permanently wet. The average owner does not, at yet, realize the durability of timber construction under water where it is not exposed to worms. The engineer can often design structures of squared timber of equal permanence and shapeliness to masonry, and of greater economy, where large sums are usually expended for concrete or stone work.

DISCUSSION.

Mr. J. W. Rollins, Jr.—Within the last few years our firm has constructed several cribs, and I shall be glad to give the members of the Society the story of our experience with them.

At the Boston Navy Yard, a sea wall 700 feet long and 45 feet high from grade — 30 to + 15, referred to mean low water, was built on a crib foundation.



Cribs were built of spruce piles, of a cob-house design, from 40 to 50 feet long and 32 feet high. Pockets were filled with stone ballast, up to grade $+ 2\frac{1}{2}$, and a heavy concrete wall built on this foundation.

As a protection against worms, the front of the crib was protected with a concrete face wall 3 feet thick, and this face wall

was strengthened with a sheet of the heaviest expanded metal. A cross section of wall is shown in the accompanying figure.

This work was done for the Fitchburg Railroad, which, in turn, did the work under the inspection of the Government Engineers.

The cribs were built to a height of about 20 feet, on launch ways, and the front sheeting for concrete was put on; also the form for the concrete, which form was fastened, at bottom, by a bolt which could be withdrawn and the form thus released.

The engineer at first objected to building the cribs with loading pockets, and insisted that the cribs should be sunk by *loading on top.*

This crib, when ready for sinking, but without ballast, would float either with front face horizontal, or else turn through an angle of about 120 degrees. With a mass of timber 50 x 32 x 32 feet, so turning about on a balance, it was a serious proposition to sink it by loading on top, especially as the crib would naturally float 10 feet out of water.

After many futile attempts to sink the cribs by this method of loading, we persuaded the engineer to let us load them in very heavy, strong pockets, and after this we had no particular trouble.

The front form being fixed at bottom of crib, and left free to move at top, we were able to make the concrete face to a true line, even though the cribs themselves worked off of line in loading.

The face wall, only 3 feet thick, with its expanded metal fastened to ends of cross lines of piles and projecting a foot into the concrete wall, was a rather difficult piece of construction, but was put in by means of a specially designed self-dumping bucket, 20 inches wide, 4 feet long and 5 feet high. This bucket could not be dumped until it was lowered to the bottom and until a set of side dogs was thus released by the weight of the bail of the bucket.

We very soon got foul of the expanded metal and tore it out or jammed it into balls of wire. It was the universal opinion of all concerned, including the Government Engineers and Inspectors, that this metal was a serious detriment to the work, and the engineer so notified the Department at Washington; but, as is often the case where telegrams have to be made with "red tape," it was a month before we got permission to leave it out where it had been torn out by concrete buckets; and by that time we had it all in again, not caring to stop the work pending the decision. Later on, divers found that, in many cases, the expended metal had been forced into the concrete forms; and, when the forms were removed, they would take great pieces of concrete with them; also, that the

metal would be "balled up," and thus prevent the concrete from getting around the obstruction and making a solid mass.

After the wall was built and backfilled, the cribs settled out of line in two or three places, the worst case involving a backward tilt of the crib.

From our experience with these cribs, it would seem that, in order to hold them to line, the bottoms of the pockets should be filled with concrete, preferably, or else with fine-broken stone, so as to give the timbers some bearing; for, by filling the pockets alone, without regard to the timber bearings, the adjustment of the load and the settling together of the filling will almost inevitably throw the cribs out of line.

At the Fore River Works, Quincy, we built concrete walls on the crib, which was according to a plan submitted by Mr. Francis, the only change made being a change from rubble to concrete.

The cribs and all the foundation work were built by the Fore River Company, and they had various troubles in their work.

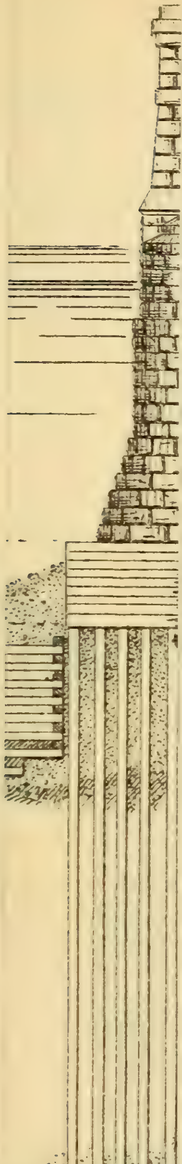
In places, the material dredged was running sand, and it took so flat a slope that the back row of piles tipped over to quite an angle, and, of course, had to be redriven. Possibly the dredging was carried too deep and too far in, and this helped the sand to run down from these piles.

Again, in filling the cribs after they were sunk, very poor material was used, and the cross-ties between the walls, made of 10 x 12 timbers, were broken by sinking an old car float on them, which allowed the finished wall to be forced out of line, cracking it badly, and also taking the back wall with it. Rods were then put in between the walls, and these have held the walls in line.

The Fore River Company sunk these cribs by loading pockets, almost to submersion, towing them into place, then holding them at true grade and line on four heavy piles at the corners, and filling, under the bottom timbers, with blocks placed by a diver.

In places, the sand slid down and filled up the dredged bottom, which fact was not found out until the crib was sunk, and then a sand pump and jets were used to get the sand out and the crib down to grade, but with rather poor success, the cribs finally being very uneven as to grade and badly out of line.

The method of tying cribs together with timber ties seems open to the objection that, unless great care is taken in filling the pockets, these ties may be broken; and, as the filling is generally done by a dredge, large masses of material are dumped, and this material is apt to strike and break projecting ties.



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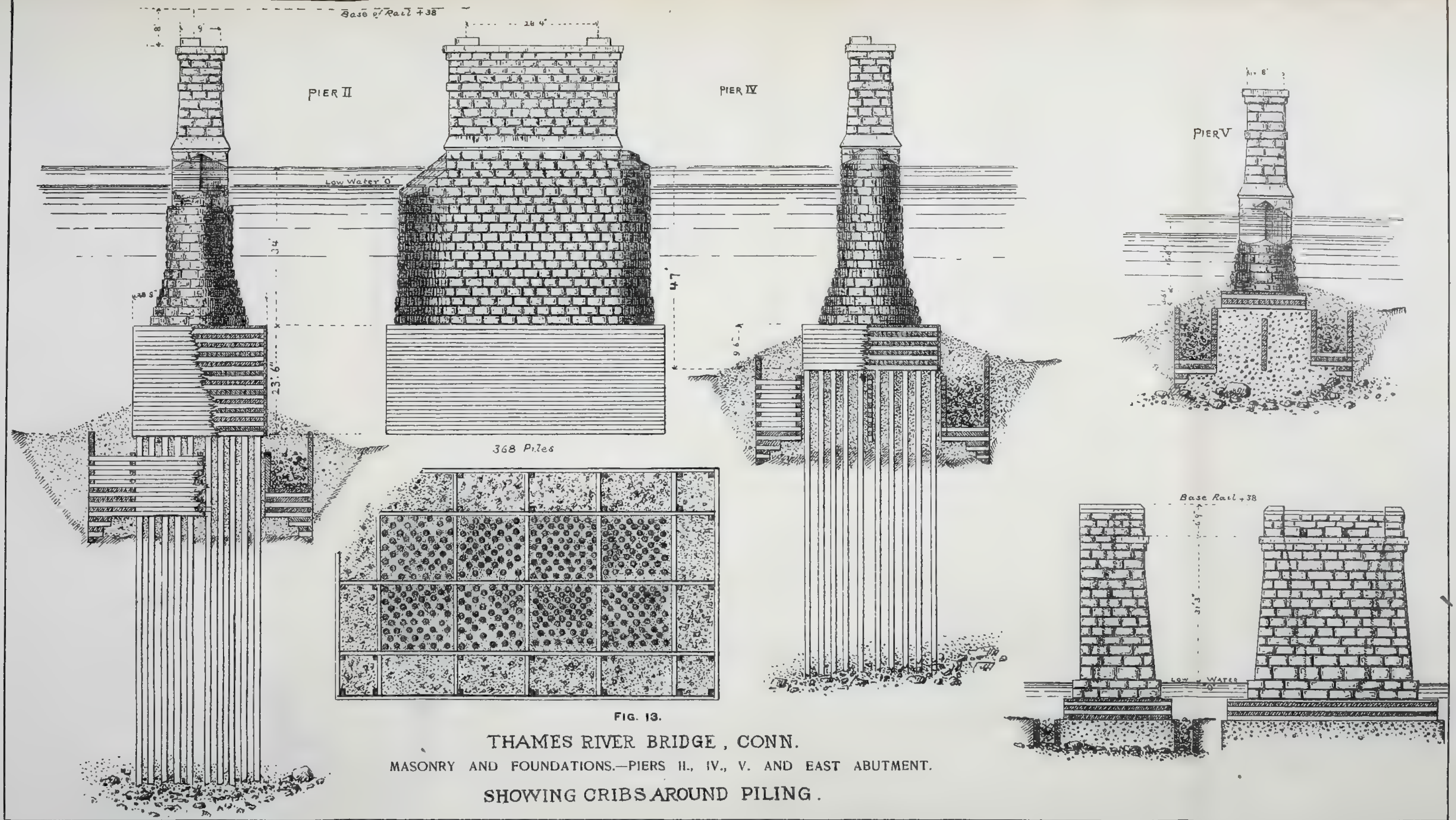


FIG. 13.

THAMES RIVER BRIDGE, CONN.

MASONRY AND FOUNDATIONS.—PIERS II., IV., V. AND EAST ABUTMENT.

SHOWING CRIBS AROUND PILING.

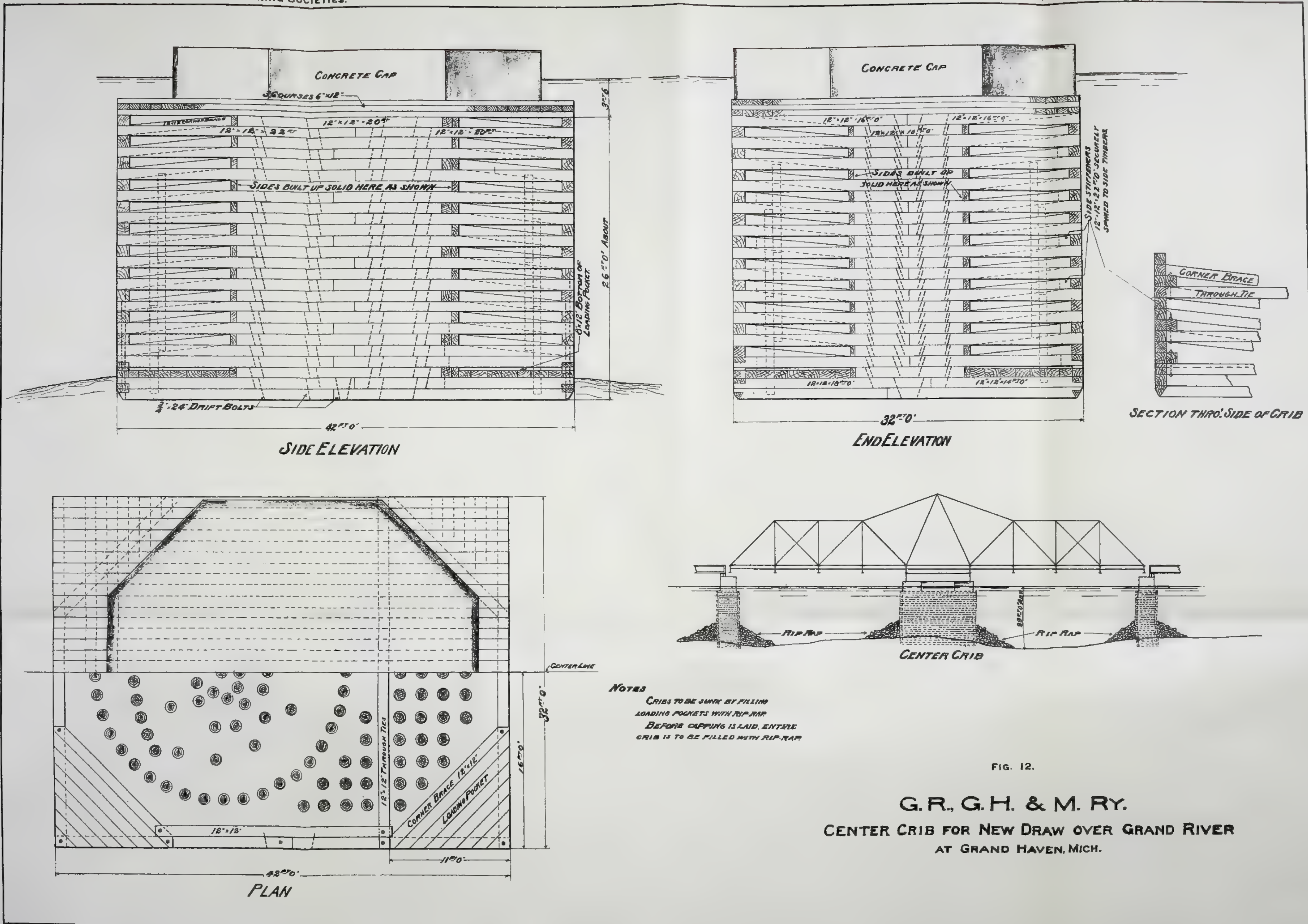
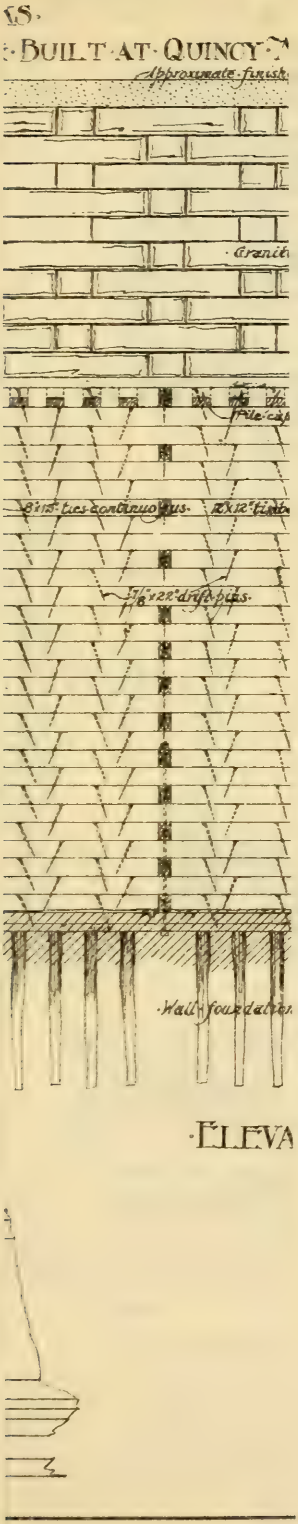


FIG. 12.

G. R., G. H. & M. RY.

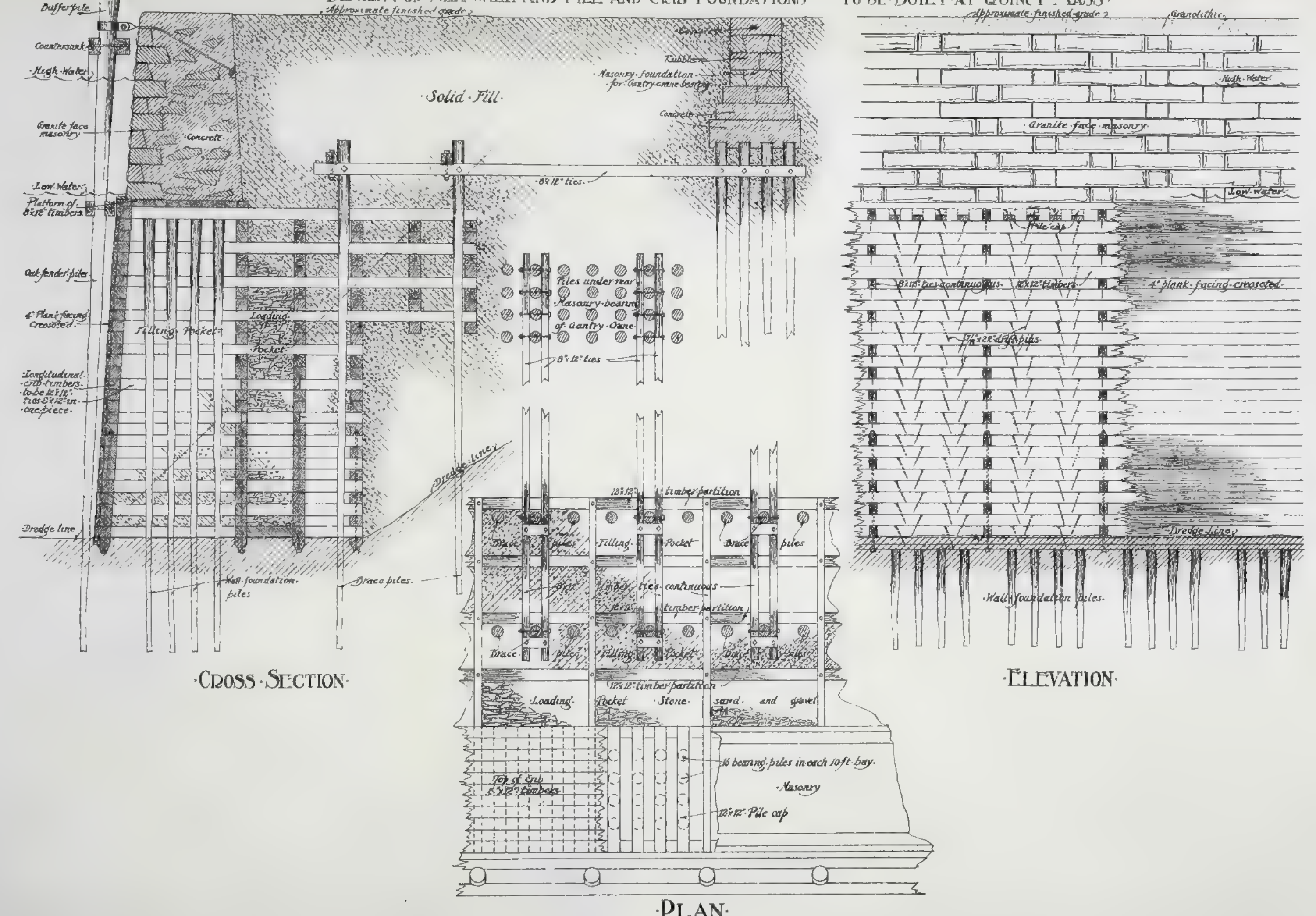
CENTER CRIB FOR NEW DRAW OVER GRAND RIVER

AT GRAND HAVEN, MICH.

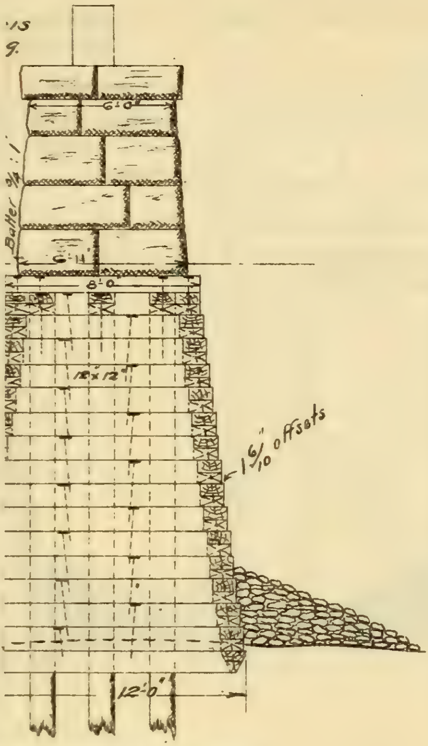


ES·
·BUILT·AT·QUINCY·
Approximate·finish
·Granite
Pile·cap
8"x12"·ties·continuous·
12"x12"·timb
7/8"x22"·drift·pins·
·Wall·foundation
·ELEVA

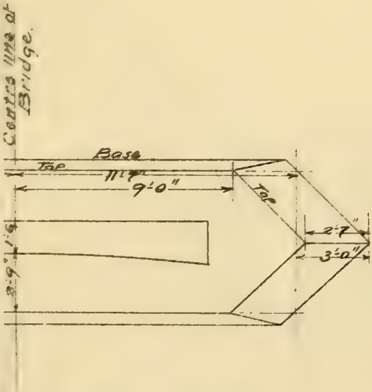
FIG. 3. ·FORE·RIVER·SHIP·AND·ENGINE·WORKS·
·DESIGN·FOR·SEA·WALL·AND·PILE·AND·CRIB·FOUNDATIONS· · ·TO·BE·BUILT·AT·QUINCY·MASS·



IER & CRIB

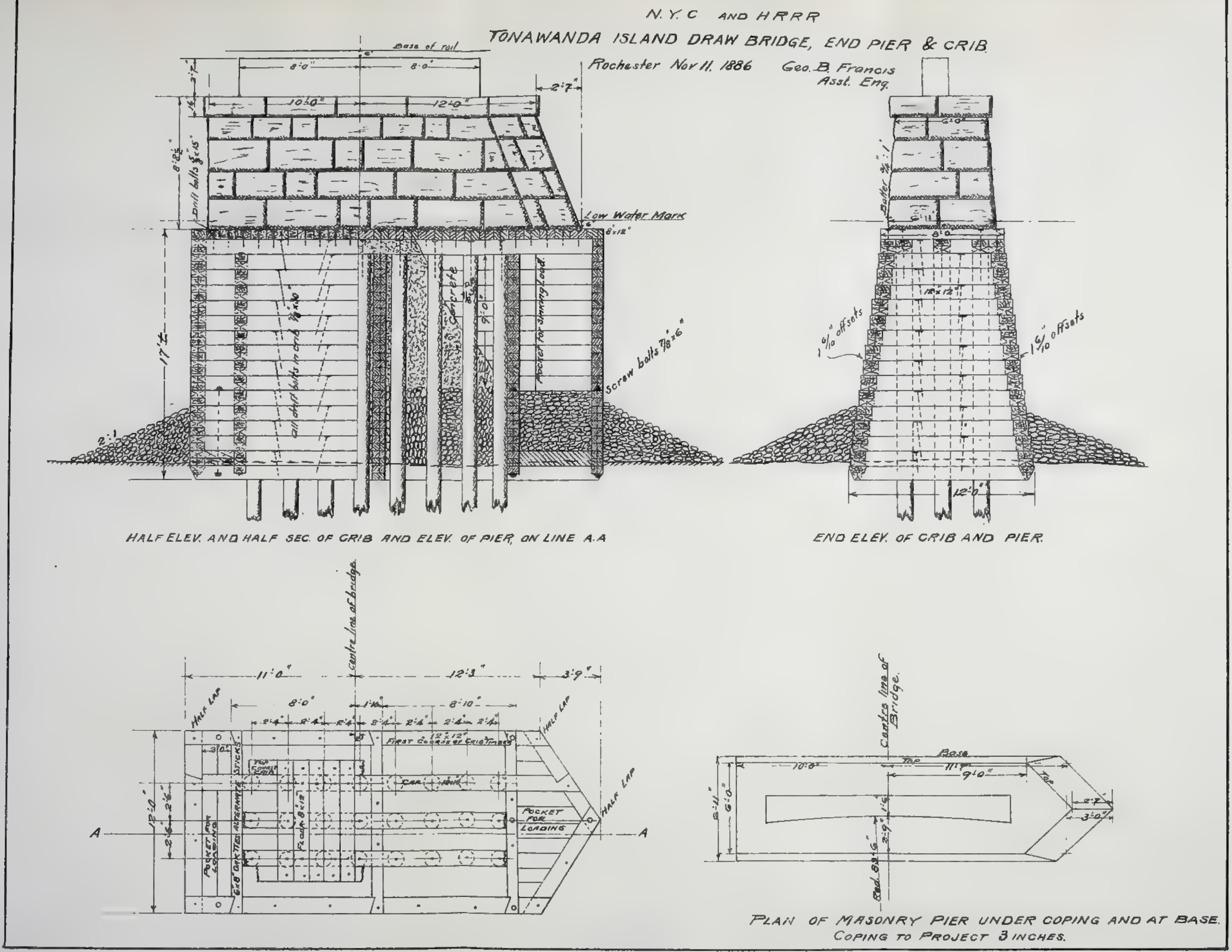


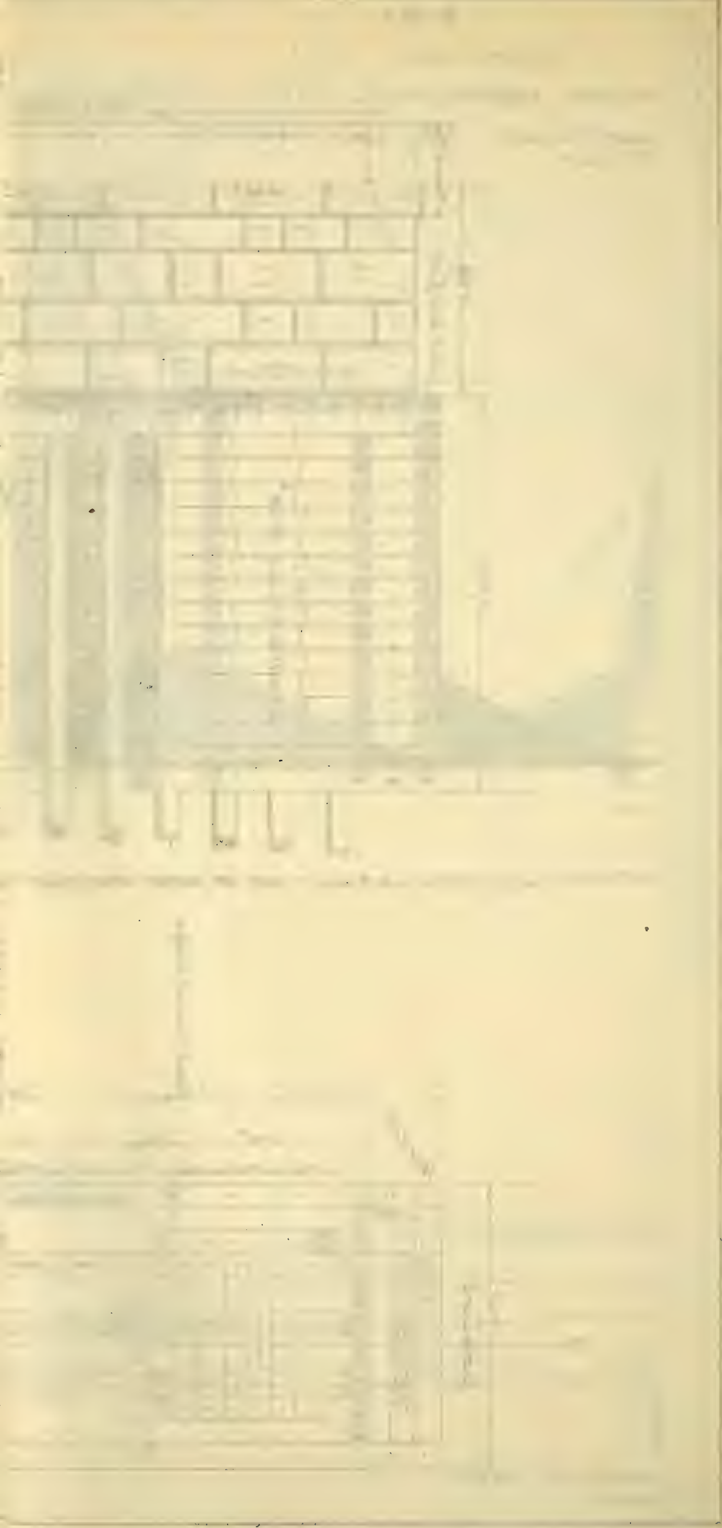
V. OF CRIB AND PIER.



NRY PIER UNDER COPING AND AT BASE.
S TO PROJECT 3 INCHES.

FIG. 2.


N. Y. C AND H R R R
TONAWANDA ISLAND DRAW BRIDGE, END PIER & CRIB
Rochester Nov 11. 1886 Geo. B. Francis
Asst. Eng.
Base of rail
Low Water Mark
Drill bolts 3/4 x 15"
All drift bolts in crib 7/8 x 10
Concrete
Pocket for Sinking Load
Screw bolts 7/8 x 6"
Batter 3/4 : 1
1 6/10" offsets
HALF ELEV. AND HALF SEC. OF CRIB AND ELEV. OF PIER, ON LINE A.A
END ELEV. OF CRIB AND PIER.
Centre line of bridge
HALF LAP
POCKET FOR LOADING
FIRST COURSE OF CRIB TIMBER
POCKET FOR LOADING
Centre line of Bridge.
Base
Top
PLAN OF MASONRY PIER UNDER COPING AND AT BASE.
COPING TO PROJECT 3 INCHES.



This same trouble developed at the Boston Navy Yard, in building a cofferdam for the new drydock, where the ties were broken by the filling, and the crib, for a great length, collapsed outward. Iron rods were then used, with heavier side construction, and these have given perfect results.

We have used timber cribs, as a form for concrete for deep-water construction, in various places and with no great difficulties.

At Bangor, for a pier in the middle of the Penobscot River, in 22 feet of water at low water, with a rise of tide of 16 feet, a crib was built of 3 x 12-inch hemlock plank, 80 x 22 feet in plan, with loading pockets. This crib was sunk into place, and all the pockets were filled with concrete, deposited by means of a bucket.

We had great difficulty here in getting the crib down to grade, it being placed between two bents of a temporary trestle, and these bents were too close to the sides of the crib to allow for dredging a space wide enough to receive the crib at the bottom of the river. A water jet was used to straighten the crib out and to level off the bottom.

Generally, in cases where cribs are to be used, great care should be taken; first, to excavate the bottom down to proper grade, or even a little below, before the cribs are sunk; and, second, as above stated, to hold the cribs in place and fill solid enough under the bottom timbers to get a proper bearing for the crib itself until the pockets are filled.

At Concord, in building a dam across the Merrimac River, we have turned the river through a canal and an opening in the masonry about 60 feet long, and we propose to close this opening with a crib, floated into position and sunk, and then drive sheet piling outside. In this case we have prepared a concrete wall to solid rock, against which the sheet piling will be driven.

For very many purposes, and in many places, cribs make the most feasible construction, and, if carefully and properly designed, they can be used for permanent work, at a far less cost than any other form of construction.

THE PLACE OF THE GREAT RAISED BEACHES IN GEOLOGY.

By Herbert W. Pearson, of Duluth, Minn.

[Abstract of an address read before the Detroit Engineering Society, January 22, 1904.*]

Before entering upon the subject of the raised beaches, the speaker discussed briefly some of the contested points in early geologic history. It was shown that, from about 1775 onward for thirty to forty years, the general belief was that all inclined strata found in elevated positions on the flanks of mountain ranges had been deposited in the exact place where found by an ancient ocean which had once covered the highest land whereon these sedimentary deposits were located.

With the advance in knowledge, however, it was seen that an elevated ocean, in continuous position at this high level, would not explain observed phenomena in the strata.

It was discovered that these waters must have often retreated some hundreds or thousands of feet from their original elevations, and, after such retreat, must have again advanced over the lands approximately to their old altitude. It was also learned that this alternate advance and recession had been many times repeated, and this oscillation in the waters could not at that time be satisfactorily explained.

Coincident with the appearance of these unexplainable difficulties in the doctrine of Werner, a rival hypothesis was proposed. Hutton, in 1795, advanced the theory that these elevated and inclined strata had originally been deposited in horizontal position and had been subsequently lifted into their present altitudes by the contraction of a cooling crust.

This doctrine of mountain upheaval, through contraction, has always been rejected by the geometers. Dutton has expressed the general sentiments of mathematicians in this regard in the following forcible language:

"The hypothesis (upheaval by contraction, etc.) is quantitatively insufficient and qualitatively inapplicable. It is an explanation which explains nothing which we want to explain."

Notwithstanding, however, that this system has been pronounced "in direct opposition to the principles of natural philosophy" (Lord Kelvin), it seemed, to the early geologists, that it better

*Manuscript received February 11, 1904.—Secretary, Ass'n of Eng. Socs.

surmounted the difficulty in explaining these retreats and returns of an ocean than the older theory.

The idea also seemed to explain, with great logic, those slight repeated submergences and emergences of coast lines, which were known to have been in continual progress since the time of Strabo.

The geologists were therefore "compelled," they were "forced" by these arguments, to adopt this doctrine of upheaval as the *fundamental base of their science.*

It was then shown that the arguments which led to this adoption were at that time absolutely inconclusive and undemonstrable; that to-day they are still less conclusive, still less demonstrable; that the decision above noted was based solely on what then appeared to be the *balance of probability,* and that to-day, in the light of more accurate knowledge, this balance is cast most distinctly in the opposite direction.

It was then suggested that those interested in these questions should examine the history of this dispute as contained in Sir Charles Lyell's "Manual" and Sir A. Geikie's "Founders of Geology."

The speaker now began treatment of his subject proper—the great raised beaches.

Illustrations and maps of the so-called glacial lakes, Warren, Iroquois, Agassiz, Ohio, Maumee, Saginaw, St. Lawrence and Algonquin, and of the sixteen Finger lakes of New York, etc., were exhibited. All of these water bodies have been delineated by various geologists as having occupied the lowlands in the Northern United States and Canada during the last glacial epoch.

The so-called Champlain Submergence of Dana was described. This inundation is supposed to have extended over the entire eastern coast of America from Greenland to the Southern United States, and, like the glacial lakes, was in existence during the last ice age.

W. F. McGee's map of the "Lafayette Flooding" of the Southern United States was also presented. This map shows that the ocean, at some very recent period of time, covered all the lowlands of the South and extended far northward up the Mississippi Valley.

This flood covered the greater portions of Florida, Alabama, Louisiana, Georgia, Tennessee and Texas. It extended to Southern Illinois at the north, and on the Atlantic coast it reached as far as New Jersey. In addition to this great area, other writers have since shown that this same submergence extended southward to Cuba, Yucatan and the Antilles.

The epoch of this Lafayette Sea, owing to its general remoteness from the glacial border, has heretofore been more uncertain

as to date than in the case of the above-named glacial lakes, but it is now demonstrable, by means of the raised beaches, that Glacial Lake Ohio and the Champlain Subsidence of the North were both *confluent with the Lafayette Flood.* All three bodies of water can thus be shown of identical age, and we thus learn that all lowlands of the North, both inland and on the sea coast, for some reason unknown and yet to appear, were submerged *at one and the same time,* and that this submergence corresponded, in time, with a vast accumulation of ice in this same region.

It was then shown that the date of the glacial period has been fixed by the estimates of Gilbert, Wright, Spencer, Andrews, Winchell, Emerson and others as within 5000 to 12,000 years of the present.

A general description was then given of the terraces, or beaches, which have been largely utilized in mapping out the above-named glacial lakes, or seas, and narration made as to the causes which had induced the speaker to undertake the systematic study of these abandoned strands.

In this study, the Boulevard Beach, at Duluth, was first considered. This terrace is supposed to have been the coast line of Lake Warren, and is from 1075 to 1077 feet above the sea.

It was soon found that this shore line was *not horizontal.* In the sixty or seventy miles of its course first examined by the author, it had a pronounced *rising inclination to the northeast.*

This northward tilting was determined by plotting to scale all altitudes, each in its proper latitude, on a prepared diagram.

It was next learned that Warren Upham, in the Eleventh Report, Minn. Geolog. Survey, had traced out a portion of the southern shore line of Lake Agassiz, in Northwestern Minnesota, and that in these terraces he had also found a rising inclination to the north, amounting, in the case of the higher beach, to about four-tenths of a foot per mile (p. 151).

The data contained in this report, and elevations secured by a personal visit to the region, were then plotted upon the same diagram which contained the Duluth beaches, previously described, each ordinate in its proper latitude as before, and we then disclosed the interesting fact that, in equal latitudes, *Lakes Warren and Agassiz had held precisely the same elevation above the sea,* and, furthermore, their beaches had precisely the *same rising inclination to the north.*

This result, which was arrived at during the early years of the investigation, furnished the key and supplied the motive for the next eight or ten years' continuous study.

Giving consideration, then, to the facts above mentioned, we see that the surface of these ancient seas, in an eastern and western direction, fell into *one horizontal line,* and this level line was then extended, by additional data, considerably to the east.

Diligent search was then undertaken, with a view of prolonging the north and south inclination as far in each direction as possible.

In a short time it was found that the upper surface of Lake Ohio, which was supposed to have been restrained by a 932-foot ice dam near Cincinnati (Claypole), fell into line as a mere prolongation or continuation of this same inclination determined as above for Lakes Warren and Agassiz, and this curve was prolonged still farther to the south, as follows:

The area of the Lafayette Sea in the Southern States had been mapped principally from a study of the silts, soils and clays of the submerged region, while the so-called glacial lakes have been delineated from limits fixed by the ancient beaches. This latter method is clearly the proper one to use in such mapping, as the silts and clays are generally deposited at some distance from a coast line, and in no case can they be depended upon to indicate the maximum elevation in the water's level. A visit was made, therefore, to the region south and west of Cincinnati, which resulted in extending the terraces and alluvial plains of Lake Ohio well into the Lafayette area, proving thus the confluent nature and equivalent age of these waters.

Eventually, by similar methods, this curve or line of inclination was extended to the northern coast of South America.

The same process above described was next used in bringing the beaches of England, Scotland, Ireland, Norway, France and the Mediterranean coasts into order, the ordinates extending from Spitzbergen on the north to Tunis and the Red Sea on the south, and the result obtained from the two continents thus treated, after ten or twelve years' continuous labor, was the production of the curves shown in Fig. 1.

The speaker then urged the profound importance of this diagram as regards the effect it may have on geological speculation, *provided it represents the facts as stated.*

For instance, these curves deny all ice dams. They affirm that all these so-called glacial, fresh-water lakes were, in fact, but arms of a salt sea. They say that all these contemporaneous submergences of the North were but fragmentary portions of one *confluent universal ocean,* which submerged the entire hemisphere from the Amazon to the most northerly part of Greenland.

Again, it is apparent that the true and nearly concentric nature

of these curves show that since these beaches were carved there has been *no movement in the earth's crust,* or deformation in these curves would have made such motion traceable.

These inferences, and many others, follow from even a casual inspection of the diagram, and all are directly contrary to the general teaching of geologists.

Our next duty should be to seek a possible explanation of the extraordinary symmetry in these curves, and in this search there is but one physical cause that can be considered adequate to the purpose.

This cause must be looked for in the assumption that the north-

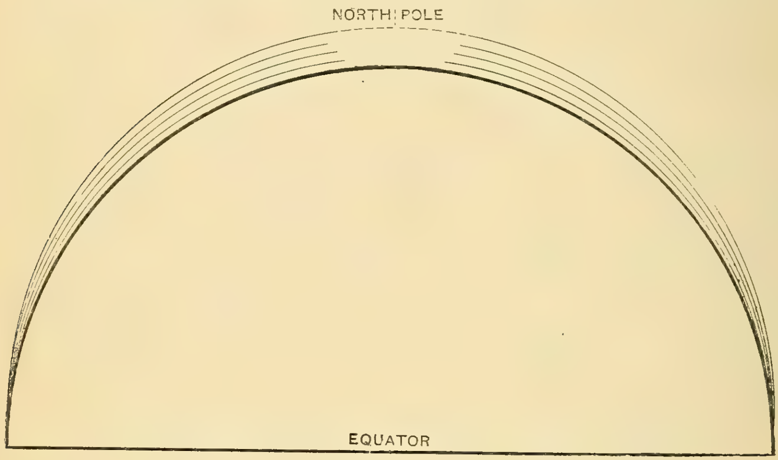


FIG. I.

ern submergence may have been due to the shifting of the earth's center of gravity under the effect of that glacial accumulation which we know was contemporaneous with the submergence.

The mathematicians have agreed that this cause may have been sufficient to meet all requirements (authorities quoted, Rev. O. Fisher, Archdeacon Pratt, R. S. Woodward, D. D. Heath, Lord Kelvin, etc.).

It was then pointed out that if this system was to be utilized in explaining our curve, a present accumulation of ice at the south should be found, the mass of which, *added to the change due to the disappearance of our recent northern glaciers,* would be competent to our necessities.

It was then shown, under the assumption that glaciers of continental magnitude are *similar solids,* and that their masses would vary as the cube of, say the mean continental diameters, and from a study of the known facts as to the Greenland ice elevations, that

Greenland contains to-day over 1,000,000 cubic miles of ice; that the Antarctic Continent, which has a diameter about three and three-quarter times that of Greenland, must therefore contain at least 50,000,000 cubic miles of ice in excess of that in the North, and this amount was found fully capable of producing the required change in the earth's center of gravity.

In other words, the decay of one cap, the building up of another, combined with the effect from the rearranged water, affords ample physical reason for the great raised beaches, for the extraordinary continuity and symmetry in their courses and for the elevation of 1467 feet which the more recent terraces would reach when prolonged to the pole.

While engaged in the above-described investigation of the shore lines of the glacial lakes, a great mass of data had been accumulated as to *older* and *higher* terraces than those shown in Fig. 1.

These ordinates, when plotted, showed the same peculiarity in structure as those previously mentioned, except that instead of running into the ocean level at the equator, they held, at that point, considerable altitude above the sea.

They also appeared to show a general and *progressive increase in depth* in these northern submergences as we went backward in time.

In seeking explanation of these unexpected results, we find as follows: Through the precessional oscillation of the earth's axis in a period of 21,000 years, and the eccentricity of the earth's orbit, winter occurs at present in the North while we are *nearest* the sun. At the South it occurs when *farthest* from the sun.

Eleven thousand years ago these conditions were reversed, and 10,000 years in the future present conditions will be again reversed, we having our winter at these periods when farthest from the sun.

Now, Dr. Croll, in "Climate and Time," has advanced much physical, meteorological and astronomical data, leading to the conclusion that such hemisphere as has its winter in aphelion must necessarily have a *lower mean temperature* than its opposite, and he argues that these lower temperatures, due to cosmical causes, may have been the occasion of glacial epochs, and, if so, such epochs would be cyclic in nature and often recurring.

This argument of Croll's has been accepted by many scientists; by others, however, it has been deemed inconclusive.

Sir A. Geikie admits the idea to contain "The first fruitful suggestion in this matter."

Alexander Winchell accepts Croll's conclusions, and Dr. Ball, with many others, admits an "astronomical cause" for ice ages, etc.

This hypothesis of Dr. Croll seemed so logical, it seemed to have so much scientific support; and as the facts as to the disappearance of a northern glacier 10,000 years ago, its presence in the South to-day and the established fact that the Southern Hemisphere is to-day the colder were all in exact accord with the requirements of the theory, it was assumed, as most probable, that explanation of these older terraces might be found in a *succession of glacial epochs* in the North, with intervals of 21,000 years.

FIG. 2.

It was now recognized that if merit should be found in this scheme, great geological results should follow these repeated inundations; explanation would be found for the Tertiary, Triassic, Silurian and other seas, which the geologists insist have repeatedly submerged the North, and, furthermore, and what was of still greater importance, it would allow us to introduce *chronology into geology,* by separting these oceanic invasions by the cyclic period of 21,000 years.

In following up this astronomical idea as to the cause of Noah's and other floods, we now map out the United States as it appeared

when some older and more elevated submergence than that of the last glacial age covered the North. We will choose a polar depth of 2000 feet instead of that of 1467 shown in Fig. 1.

Fig. 2 represents the Eastern United States during such northern inundation. The beaches of this period indicate a depth to the waters of 845 feet in Southern Florida, 1150 feet at Cape Hatteras, 1312 feet at New York City and 1380 feet in Southern Nova Scotia.

The ice cap, the cause of this submergence, is shown in dark shading in the Northern regions, and has been located from limits fixed by American geologists for the last glacial invasion (7th An. Rep. U. S. G. Survey, Plate 8).

Examination of Fig. 2 discloses the following facts: Nearly all the Eastern and Southern States are found buried under an accumulation of ice, or covered by the waters of a glacial sea. The Appalachian Mountains rise above the waters; likewise an elevated area in Missouri and Arkansas designated as Ozark Island.

We learn, also, that the submerged areas, northward from the equator to Long Island, aggregate at least three million square miles or more, and we know that much of this lowland to-day bears the most prolific vegetable growth in the world.

This brings forward the question, What has become of the forest débris which must have been prostrated by this advancing sea?

The geologists are unanimous in agreeing that the wide ocean has repeatedly passed over the lowlands of the North; they are positive that vast areas have been so submerged as recently as within a few thousand years, but, in so far as we can learn, not one of these geologists has attempted, or even suggested, that geologic provision be made for the vegetation which such seas would necessarily overthrow in their advance.

Notwithstanding this neglect, however, guided as we now are, by a hypothesis which calls for the devastation of the present forest areas by oceanic waters in the near future, we cannot avoid consideration of the problem as to what will become of this great mass of vegetation.

It is plain that the débris of forests drifting in the sea will primarily be subject to the influence of oceanic currents; if we would follow, therefore, this material to its final resting place, we must attempt determination of some law, if such exists, by which we can predicate invariably the geographical position and the direction of flow of these streams at any one of the many different elevations of the sea level we have been discussing.

In pursuit of this law we reason as follows: Under our hypoth-

esis, a vast accumulation of water now submerges the South. These waters will soon be compelled to begin their journey to the North. Let us assume that this transfer has commenced, and let us attempt to discover the route or path these waters must adopt.

The earth's surface at the equator has a motion to the east, due to the daily rotation of, say 1040 miles per hour; in latitude 70 degrees South the velocity is but 350 miles per hour.

Let us now take a unit of this northward-moving water at latitude 70 degrees in the South Atlantic, where the eastward motion of the earth's surface is 350 miles per hour, and move it instantaneously to the equator, where the surface has a velocity of 1040 miles per hour.

We then observe that this unit immediately starts an apparent movement toward the coast of South America at the rate of nearly 700 miles per hour.

This transfer of water will certainly require a period of months, instead of being instantaneous, as supposed herein; but the fact remains that if water is passing northward from the given position in the South Atlantic, it can never reach the equator until it has undergone an acceleration in its eastward motion of 700 miles per hour.

This acceleration may be obtained by any one of three methods. The waters may, in their northward journey, press against other currents of water; they may be crowded to the east by the irregularities of the ocean bottom, but their final acceleration must certainly be acquired from their impingement on the entire eastern shore line of South America, from which there results the necessity of assuming that the waters adjacent to this coast will be heaped or piled up *far above the normal level of the sea.*

This heaping of the waters on these shores, combined with the fact that the easterly apex of the continent is considerably south of the equator, compels the diversion of the northward-moving current into the bight of the Gulf of Mexico, where these waters receive the final acceleration due to the earth's rotation.

We see, also, that in this gulf the surface of the ocean must necessarily be far above the normal sea level, and, consequently, the escape of these waters through the straits of Florida at a rate of four miles per hour needs no further explanation. This velocity of flow is due to the hydraulic head in the Gulf of Mexico, and the convexity of surface in the escaping current is a physical necessity from the attendant circumstances.

Waters flowing from the gulf and still moving northward are now always traveling faster to the east than the surface of the

earth over which they are moving. They are, consequently, compelled to a direction of northeast, and, having left the Florida shores with a velocity of about 1000 miles per hour, they must suffer retardation of something like *600 miles per hour* before reaching the coast of Scandinavia, where the final retardation must be accomplished by the crowding of these waters against the coast lines of Norway and the British Islands. Here, also, the sea level must necessarily be deformed and raised far above the normal.

It follows, from this discussion, that if water is passing northward in the Atlantic, it can by no possibility follow any other route than that of the present Gulf Stream. It follows, also, that with any change in shore lines, due to the elevated seas we have under consideration, the paths and positions of the ocean currents of the period, with their direction of flow, can still be determined through application of the same analysis.

In confirmation of this idea of deformation of sea level by ocean currents (see discussion by William Ferrel, *Science,* Vol. VII, p. 75), reference was made to Vol. XXII, *Encyc. Brit.,* p. 608, where the North Sea and Atlantic are shown to be from two to five feet higher than the Mediterranean, and to the United States Coast Survey Report for 1899, where many lines of level are unanimous in showing the same condition between the Gulf of Mexico and the Atlantic, the gulf being the higher, by various results, up to over one meter.

In the first case, this artificial elevation in the North Sea was held to be "difficult to explain on mechanical principles." In the case of the Coast Survey, the result from leveling was deemed so improbable that the level net adjustment for the United States has been fixed under the assumption that the waters of the Atlantic, the Chesapeake and the Gulf of Mexico *are at one elevation.*

All these decisions are clearly erroneous; they are in opposition to known fact; they are in opposition to hydraulic principles; and in future discussion of these questions consideration must be given by engineers to Ferrel's law in these matters.

From the results of our study of ocean currents, we now place on Fig. 2 certain arrows, which represent the position of the Gulf Stream at this epoch of northern submergence, and its approximate direction of flow, as determined by our argument.

We next examine, with a view of learning where currents flowing in the directions indicated would transport the débris from our overthrown forests, and make search for bays, estuaries, lagoons or catch basins, wherein drift material such as described might become lodged or embayed in permanent position.

At the first glance it is seen that the boundaries of this inundation, as shown in Fig. 2, *reproduce almost precisely the boundaries of the carboniferous area* in the United States.

The speaker then exhibited the maps of coal areas as contained in the American Supplement to the *Encyc. Brit.* (Henry G. Allen Co.), and, under the assumption that a strong current was pouring through the channel in Central Pennsylvania, between the north end of Appalachian Island and the ice cap, by reason of the elevated surface of the interior waters, demonstrated that the coal areas in the States of Pennsylvania, Ohio, West Virginia, Kentucky, Tennessee, Alabama, Illinois, Iowa, Nebraska, Missouri, Arkansas, Kansas, Texas and Nova Scotia were, in each particular case, found in the *precise situation where the indicated currents of this oceanic invasion would have accumulated the vegetable material due to such flooding.*

We have thus traced our forest débris to its final resting place.

The great coal deposit in Southern Wales, owing to the enlarged scale of the ordnance maps of England, was shown as being subject to the same law of drift accumulation with still greater accuracy.

The Gulf Stream approached submerged England from a direction south of west. It is clear, therefore, that explanation for this deposit must be sought in some barrier exceeding 1300 feet in altitude, extending along the northern and *particularly* on the eastern side of the field, where the coal should certainly cease where the barrier ceases.

One-inch Ordnance Sheets, Nos. 231, 232 and 250, show a mountain chain in Southern Wales extending in an east and west direction and reaching an altitude of over 2000 feet.

At the eastern end of this chain a range, or, rather, a series of hills, having elevations of 1834, 1814, 1557 and 1374 feet, projects directly south. This range, which would appear as many small islands at a time of high-sea level, terminates about one mile north of the town of Risca.

From the 1374-foot barrier near this village the descent is abrupt to a level of about 700 feet.

This chain of islands is the most easterly obstruction to high-level currents in Southern Wales, and the combination of mountain range on the north with these islands at the east makes a most perfect arrangement, or catch basin, for the interception of floating vegetation. It is clear, also, that such interception must have ceased one mile north of Risca, where the elevated range reaches an end.

It was then shown by Woodward and Goodchild's geological

map of England and Wales that the coal of Wales is located within the basin above described, and that its extension southward terminates precisely where our barrier terminates—one mile north of Risca.

In a similar manner the outcrops of the coal areas of Belgium and Germany were shown to be located invariably on the elevated coast lines of a northern submergence.

Having thus shown the principal coal deposits of the world to have been located *one hundred times in succession* along the sea beaches of a submerged north, the speaker asked, or, rather, demanded the privilege of using the bounding limits of these areas, in themselves, as *original beaches.*

If this is allowed, these coal areas will then supply *one hundred* such diagrams as Fig. 1, and will confirm, to an enormous extent, the accuracy with which these curves had been derived from the raised beaches.

Reference was made to the fact that the drift origin of coal to this time has been generally rejected. This rejection has been based on the following reasons:

First. No drift theory could supply sufficiency of material.

Second. Perfect ferns "always on the top of the seam" were considered as "incompatible" with driftage.

Third. Stumps and roots in the soils beneath coal beds have been considered as "demonstrative evidence" that the vegetation grew where the coal is found.

It was then shown that these conclusions are founded on most imperfect consideration of the questions involved. For instance:

First. The submergence of continents, so universally recognized, will undoubtedly supply sufficiency of vegetation.

Second. The floating rafts of the South, some of which have exceeded 100 miles in length, are invariably covered with a dense growth of ferns. When these rafts sink, it is certain that these ferns will descend to the bottom, *each in perfect condition,* and that they will always be found on "the top of the seam."

Third. Floating vegetation borne on a rising sea will be continually advancing over a region of overthrown and devastated forests. When this material sinks, it is almost certain, therefore, to find lodgment on a "fossil soil filled with stumps and roots in position exactly as they grew."

Attention was now called to the effect the new facts brought out in this discussion must have on geological speculation of the future. For example:

Equally with the great raised beaches, the coal beds of the

world *reject the doctrine of the upheaval of mountains;* these items supply that geological evidence which has heretofore been lacking in confirmation of mathematical conclusion in this regard.

Again, the 100 coal beds, if we make allowance for the barren measures when the waters were too deep for the barriers, could all have been laid down in 3,000,000 years, or say during 140 submergences.

If we now assume the carboniferous rocks to represent one-third of the geological column, this would allow all rock strata that have been derived from water to have been deposited in 9,000,000 years. Here geologic data again support the results from mathematical analysis; Tait and Newcomb having each determined that water could not have existed on the globe for a longer period than 10,000,000 years.

It was then stated that the apparent slight oscillations in coast lines during the historic period, which have heretofore been considered as confirmatory of the doctrine of continual movement in the earth's crust, could now be demonstrated as being due to *movement in the sea;* that these motions were periodic in their nature; that the length of this period had been determined approximately, and that the direction of this movement, upward or downward, for any given century in the past, could now be learned through mere inspection of a sinuous curve which had been derived from these oscillations. (See article, "Oscillations in the Sea Level," in the *Geological Magazine*, London, April, May and June, 1901.)

The speaker closed by urging, with much emphasis, the necessity of entering upon that revision in geological speculation which the raised beaches seem to require and which the geometers have long demanded.

Modern geology is now, and always has been, in an attitude of direct hostility to mathematical and physical reasoning. The absolute *law* which prevails in the World of Coal; the certainty with which the universally distributed terraces deny upheaval—these facts, which are incontestable in themselves, offer a means of escape from the present situation, and, sooner or later, we shall be compelled to avail ourselves of this opportunity.

The whole weight of the argument from the coal beds, and from these traces of Werner's elevated and universal ocean, is in favor of our abandonment of the old doctrine of upheaval and of the reconstruction of geological science on the basis of a rigid and inflexible crust.

It is in this manner only that geologic fact, geologic theory and mathematical conclusion can be brought into harmonious accord.

OBITUARY.

William C. Ogden.

Member of the Boston Society of Civil Engineers.

William C. Ogden passed away at his home in Dover, N. H., October 12, 1903, after a long and severe illness of typhoid fever. He is survived by a widow, father and mother and two brothers, having lost his only child about two years previous to his death.

Mr. Ogden was born February 4, 1866, at Troy Hills, N. J.; was educated at the public schools of that place and at Rutgers College.

His first engineering work was on topographical surveys in New York State and in Michigan, in which latter State he made a survey of a portion of the Military Road Lands.

In 1893 he was appointed Assistant Superintendent of Construction of the Fortifications at Portland Head, Me. In 1894 he was Assistant Engineer in the construction of a reservoir at Yonkers, N. Y., and on the construction of the Poughkeepsie Electric Railway.

During 1895 and 1896 he was associated with the late W. E. Worthen, Civil Engineer, of New York, and from that time until his death he was located at Dover, N. H., where, by perseverance, he had succeeded in building up a prosperous business.

At the time of his death he held the office of City Engineer of Dover; was the Civil Engineer for the Commission appointed by the Governor of New Hampshire to lay out and construct a boulevard along the entire coast of New Hampshire, besides doing nearly all of the engineering and surveying required in the section of the State in which he was located, and his reputation extended over to the State of Maine, where, at the time of his death, he was employed as Engineer on a water-supply system.

Mr. Ogden was a man of convictions, and dared to follow them in the walks of everyday life. It was not his way to ask if a measure was popular; it was enough for him to know that it was right, and for this reason the advocates of temperance and any worthy reform found in him one of their staunchest supporters.

His was a pure, manly, Christian character, and he could be depended upon, wherever his word or deed was needed, for the right and true.

He was a member of the Washington Street Freewill Baptist Church of Dover, N. H., and for two years was Superintendent

of its Sabbath school. He also served for several years as President of the Young Men's Christian Association of the same city.

In closing our brief tribute to our comrade and friend, we can do no better than to quote the words of one who had the privilege of knowing and respecting him, as follows: "During the last three years it has been my good fortune to have Mr. Ogden connected with me as a Civil Engineer on much of my work, and by intimate association with him I learned not only to respect and admire him as an Engineer but to love him as a man. It is rare to find one who combined his rare professional talents, his good judgment, his unbounded energy and perseverance, his fertility of resource, accuracy of workmanship and his never-failing modesty, courtesy and patience with his noble character as a man. To know him was a privilege; to have him for a friend, an inspiration, and to lose him, a deep and lasting grief, and his friends and business acquaintances and the whole community will mourn their loss in his untimely death."

S. Foster Jaques,
A. W. Dean,
Committee.

Frank Prescott Johnson.

Member of the Boston Society of Civil Engineers.

Frank Prescott Johnson was born in Burlington, Iowa, April 1, 1859. When four years of age his parents moved to Washington, D. C., and, after a residence of six years in that city, came to Waltham, Mass., where he resided for the greater part of his life. He graduated from the Waltham High School in 1878 and from the Massachusetts State Agricultural College in 1882.

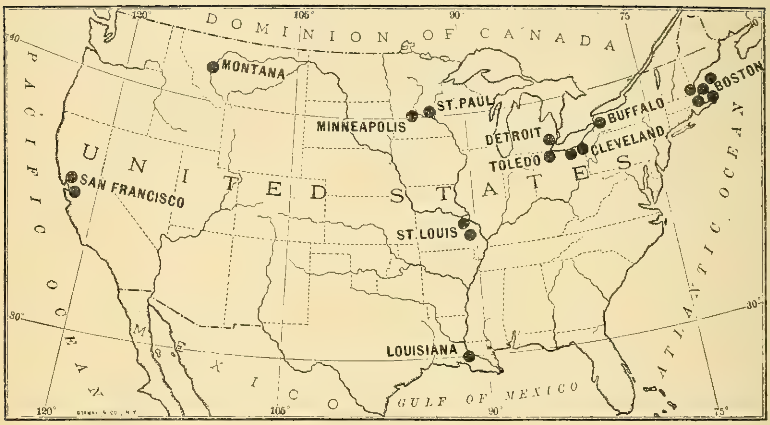
His early experience in engineering was in connection with the laying out of the Central Massachusetts Railroad, sewer construction in Boston and waterworks construction in Newport, R. I. Later, he succeeded to an engineering business in Waltham, served as Inspector for the Waltham Board of Health, and in March, 1893, was elected City Engineer. In the following year he was also made Superintendent of Sewers. In the summer of 1896 Mr. Johnson became engaged in the contracting business, and was ultimately permanently located in Bramford, Conn., where he developed a quarry for the manufacture of crushed rock and established a corporation known as the Tide Water Trap Rock Company, of which he was manager at the time of his death.

While riding a bicycle, on the evening of November 1st, the chain became misplaced and he suffered a fall which produced an internal hemorrhage and caused his death November 2, 1903.

Mr. Johnson became City Engineer and Superintendent of Sewers of Waltham at a time when the growth of the city and popular demand required an economical and businesslike administration of two growing departments. He introduced new methods and obtained creditable results.

As an Engineer, Mr. Johnson was an advanced thinker. It was characteristic of him to be looking ahead to see what improvements could be inaugurated, and, in work which he had charge of, he could be relied upon to adopt new methods wherever they could be used to advantage. He was not satisfied to follow in well-beaten paths simply for the reason that they involved fewer obstacles. He was active and enterprising and possessed that indomitable perseverance necessary to put his ideas into effect.

BERTRAM BREWER,
JOSEPH R. WORCESTER,
Committee.



MAP

Showing the locations of the Societies forming

THE ASSOCIATION OF ENGINEERING SOCIETIES.

(Each dot represents a membership of one hundred, or fraction thereof over fifty.)

Editors reprinting articles from this journal are requested to credit not only the JOURNAL, but also the Society before which such articles were read.

ASSOCIATION OF ENGINEERING SOCIETIES.

Organized 1881.

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THE RECONSTRUCTION OF FOUNDATIONS FOR THE HOTEL WOLLATON, BROOKLINE, MASS.

BY DANA M. PRATT, MEMBER OF THE BOSTON SOCIETY OF CIVIL ENGINEERS.

[Read before the Society, February 4, 1903.*]

SOME five or six years ago, the Hotel Wollaton, at 1070 Beacon Street, Brookline, Mass., was condemned as unsafe for occupancy, on account of the continued settlement of its foundations.

This settlement began during the erection of the building, and continued year after year, with the result that the walls were thrown out of plumb and the floors out of level, and large cracks appeared in all parts of the building. For some time it remained empty and fenced off from the street, to protect the public from falling walls, if such collapse should occur.

The hotel has six stories, with twelve suites, and is approximately 80 feet square. The walls are of brick above, and of heavy stone below, ground, the whole resting upon ordinary pile foundations. The location is on lowland, which might be called a "pot-hole." This lot had been filled, over a portion of the site, up to the level of the street or to about grade — 21. This was the state of affairs when the hotel became the property of Newhall Brothers, of Boston. The owners engaged French & Bryant, of Brookline, to devise some method of strengthening the foundations, so as to make the building once more habitable. The plans furnished the engineers were blueprints of the roof and the several floors and the framing plans; also records of the soundings. Before commencing on the descriptions of repairs, it may be well to go back to the time when the first foundations were built.

* Manuscript received February 26, 1904.—Secretary, Ass'n of Eng. Socs.

The original piling plan showed about 1000 piles, or treble the number used in the new foundations.

Rumor has it that while the lower walls were going up, settlements were noticed by the masons. Walls and floors, which were left plumb and level, were found to be out of position a few days after they were laid; and, as each successive story was reached, the floors were made level. This remedy was only temporary, and of its effects I will speak later. By the time the building was done, or soon after, it was feared the foundations were too weak, and some one tried to fix them by additional outside piles and steel beams, but as far as any material benefit to the foundations went this operation might have been omitted. Owing to changes in the original building plans, after some of the foundations were built, a great many piles were driven which were not loaded; these were uncovered, holes were cut in the walls, and through the latter were placed I beams, which rested on these idle piles. The beams were pinned off at the walls and became a part of the support. These beams were mostly 15 and 20 inches deep, and, in our work later on, we found some to be from 20 to 25 feet long, supporting the wall entirely. This made a very long span for such a concentrated load, causing a deflection in the beams of nearly a foot.

At the rear wall of the building, where the settlement was the greatest, the piles were capped by a platform of three layers of 6 x 6 inches hard-pine timbers, reinforced by a layer of concrete, the walls resting directly upon this structure. All these repairs proved futile and the building still settled very slowly.

The foregoing sketch gives an idea of the conditions prevailing at the time we took hold of the work.

The first thing to be done was to examine the borings, seven in all, taken by the B. F. Smith Company.

There were seven soundings, a fair average being shown in Fig. 1.

These tests were not considered sufficient, and two 120-foot holes were made by the Brookline Waterworks to approximately grade — 100, the main purpose being to determine if suitable hard material was near enough the surface to make the use of iron piles economical. These tests showed that from grade — 30 to grade — 100 the material was sharp black sand, mixed at intervals with a little clay and gravel, until at the extreme depth it was so compact as to be almost impossible to drill.

This showed that iron piles would not be appropriate, and that the stratum of gravel at about grade — 25 to grade — 30 was the firmest for supporting the piles. (See Fig. 1.)

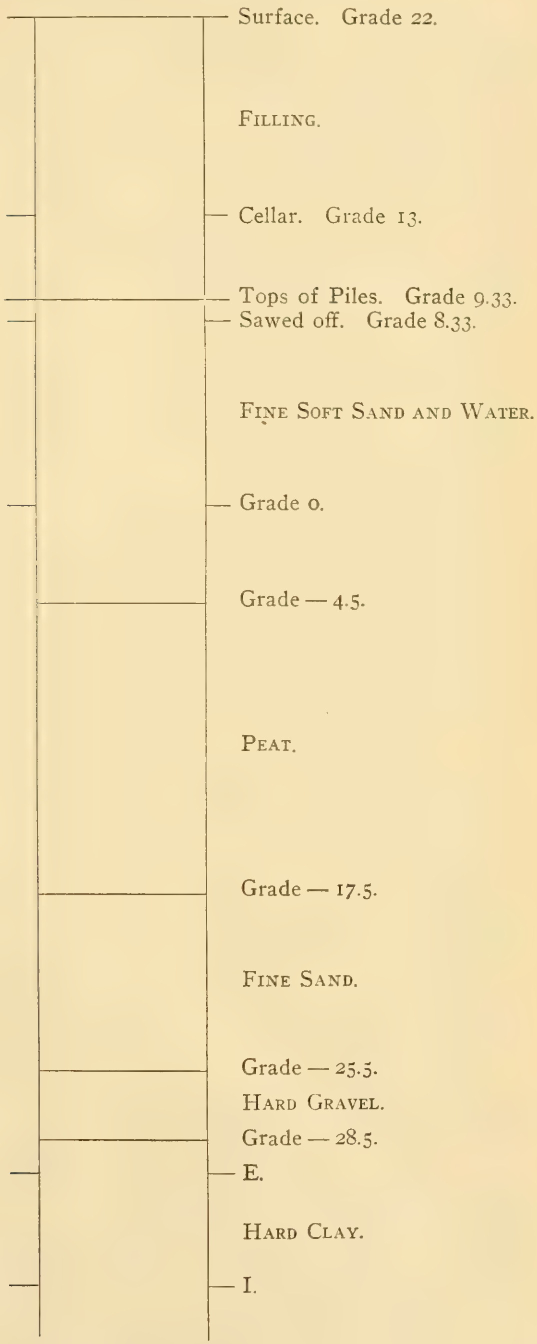


Fig. 1. Average Sounding.

E = Desired position of points of exterior piles.
F = " " " " " interior "

The following schemes were considered in the preliminary studies:

1. Loading the building and moving easterly 40 feet where the soil was firmer.

2. Open-caisson method with some wood and some iron piles, the caissons proposed being 4 feet in diameter. This method would have cost at least $16,000.

3. Moving the building westward about 90 feet on to a temporary pile support, and while it was in this position lay new foundations, after which the building was to be moved back upon them. This estimate footed up to $22,000. This method was abandoned largely on account of the walls, which were so cracked that it was feared they would not be able to stand the journey. These estimates gave from $15,000 to $22,000, and, moreover, moving the building was considered a doubtful experiment.

4. The method finally adopted was to repair the foundations and level the building, but not moving it laterally. While the foregoing studies were under way a good many measurements were made. Levels were taken over the whole lot and plotted on a one-quarter scale plan. The building was closely measured on the outside and accurately plotted. The inside arrangements were taken from the building plans and verified by observation. Levels were taken on the first, second, fourth and sixth floors in corresponding positions and the settlements compared by floors. The settlements shown by the different floors agreed generally within a fraction of an inch, a portion of any discrepancy, no doubt, being due to doing the leveling on a floor and the remainder due to the manner in which the floors were laid. The easterly front corner was in comparatively firm ground and was assumed to have retained its original level. Whether this was so or not is of no moment, for we aimed to bring all other portions of the building to this highest level. The greatest settlement on any portion of the floor was 0.92 feet, or 11 inches. Its location was on the west side, about three-fourths the distance to the rear. From these levels the settlements were contoured every 0.05 feet difference in elevation.

In order to detect any settlements which might occur during the work, especially while pile driving, small nails were driven at various points, both inside and outside the building. There were sixty-four in all; twenty-five being outside and thirty-nine inside. These were placed at salient points, such as angles in the walls, piers, elevator wells, etc. Before any work was commenced levels were taken on the telltales to the nearest 0.001 of a foot and the date noted. During the work levels were taken on these telltales at

frequent intervals, sometimes daily, especially during pile driving; the progress of the work being noted each time. These elevations were tabulated and constantly examined. In addition to these, some of the cracks in the walls were plastered with mortar. This latter method, although showing occasional settlement, was unreliable. By the table we could determine at all times the state of the walls and the chances of a collapse.

Measurements of all piers were necessary for the proper placing of piles, and also a plan of all iron beams in the first floor. These beams were placed every 4 or 5 feet through the whole floor, and the inside piles had to be located very carefully.

Location of Building.—Four offset lines were run parallel to the four sides of the building, at as short a distance away as practicable, and the ends thoroughly tied in. At various points, on the first and sixth floors, offsets were taken. The front side was found to be 0.15 to 0.20 feet out of plumb and leaning toward the rear. The back walls on the easterly portion leaned 0.19 feet toward the street, and on the westerly end leaned 0.46 feet away from it. The east wall leaned west 0.66 feet and the west wall leaned west 0.70 feet. The weight of the building, with live and dead loads, was calculated as 4000 tons, and, by means of the framing plans, we were able to determine its proper point of application to the walls. This weight was taken in sections, about forty in all, and the necessary piles computed for each section.

The general plan of the new foundations is shown in Fig. 2. Spruce piles were driven outside the building and hard-pine piles in sections inside; the tops were concreted around and capped with granite. Upon the granite caps were I beams, placed directly above the rows of piles; upon these I beams were cross I beams running from inside to outside of walls, and upon these last were a double row of beams, which carried the walls directly. All of these beams were covered with concrete. This is shown in detail in Fig. 3.

The work of rebuilding was divided into three parts, as follows:

1. The excavation, grading, sawing off piles, pumping and backfilling was let by contract to J. H. Sullivan. Bids for this work ranged from $3000 to $5200.

2. This contract included tying walls, loading and leveling building, driving piles, removing masonry and handling iron work and boiler. This contract was let to Isaac Blair & Co., of Boston.

3. The owners thought best to do all rebuilding of masonry, cutting holes for beams, setting stone caps for piles, beams, carpenter work, etc., themselves, and this was done by various laborers,

under the direction of a foreman accustomed to the construction of large buildings.

Work was commenced about October 20, 1899, both contracts being carried along together. The first work was to tie the walls of the building together on the second and fourth floors. For this purpose heavy iron rods, with turnbuckles, were used.

The first piles were driven October 23d. All piles were numbered and the penetrations recorded. It may be well to give a few

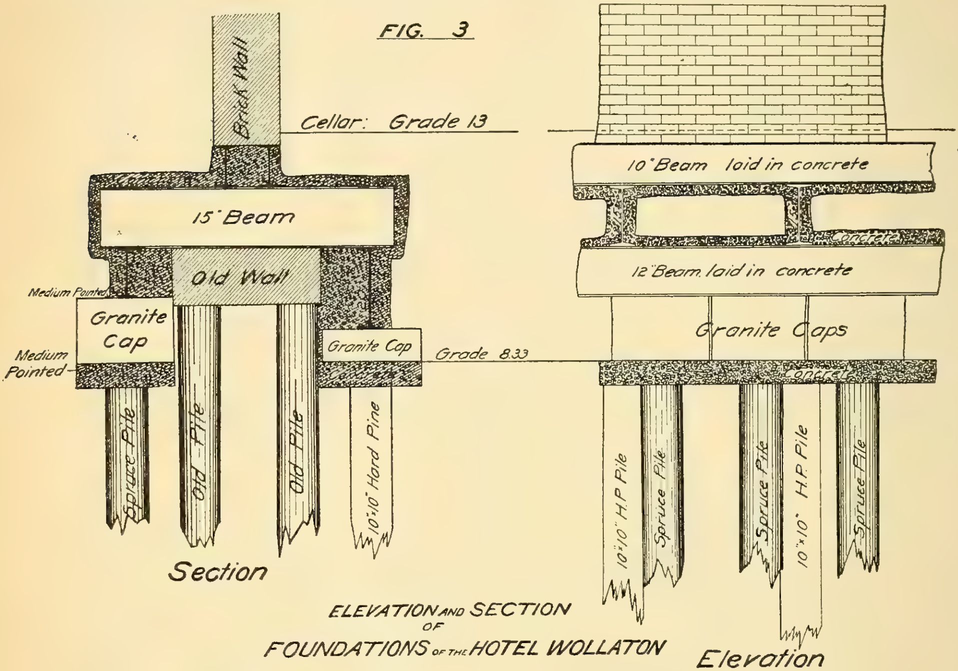


FIG. 3. ELEVATION AND SECTION.
Scale, 1 inch = 4 feet.

words of explanation about them. I have previously mentioned how few there were compared with the original number. The ordinary loads given to the piles supporting buildings in Boston are 8 to 10 tons, while some of our piles were figured as having to carry nearly 50 tons. This loading was so excessive, that we searched pile-driving records to find a precedent. In *Trans. A. S. C. E.*, vol. 2, p. 155, was an article on pile tests made in Buffalo.

The conclusion drawn from these tests among others was that 1000 pounds per square foot in clay, sand and gravel was conservative for downward skin friction for a static load. The proper lengths of inside piles were worked out as follows:

The portion of the load to be borne wholly by the inside piles was 3000 to 3250 tons. By using 100 piles inside this meant 32.5 tons per pile. By using hard-pine timber, 10 inches square, the friction area of the pile is 3.3 square feet for every running foot, or 3300 pounds for the frictional resistance per lineal foot. The average load on a pile being 65,000 pounds, this gave 65,000 ÷ 3300 or 20 feet as the necessary penetration in bearing soil.

Keeping in mind that the first 25 to 30 feet was in very poor material, peat, in fact, we have 45 feet for the required length of pile; the outside piles being more numerous, were called 40 feet long.

The first pile driving was done in front of the building where the filling was the greatest. This driving was done before any excavations were made and the diggers followed shortly. As the earth was removed the piles were sometimes found to be out of plumb and out of position, owing to their striking sunken logs. After this, the excavation, down to about grade — 10, the ordinary water level, was done in advance with better results. Owing to the very ragged original foundations and other obstructions the piles could not always be driven where desired, and this is shown in the poor spacing and ragged lines shown in Fig. 2. This also necessitated the use of caps in many cases, and on this account it is quite possible that some outside pile loads reach 50 tons.

The pile driving outside was done with a Warrington steam hammer of the Nasmyth type. The hammer was made by the Vulcan Iron Works, of Chicago, and consisted of a frame supporting a steam cylinder, to the piston of which is attached a heavy cast-iron ram. This whole apparatus rested directly on the pile top; the ram traveled 19 inches and struck sixty to eighty blows per minute, and the pile was practically on the move all the time and the jar reduced to a minimum. The total weight of this iron work resting on the pile was 6500 pounds, the weight of the ram itself was only 1700 pounds. This hammer had to be kept well oiled, and at first the steam exhaust scattered the oil to the sides of the building, discoloring the light brick to a yellowish brown. It was therefore found necessary to protect the walls, and a canvas of large dimensions was hung from the walls. Taken all in all, the pile driving was perhaps the most interesting part of the whole procedure. The outside pile driving commenced October 23d and ended December 7th. There were 173 of these, and they were all spruce, furnished and driven by the contractor for $6 per pile of 40-foot length. Seventeen piles were spliced with a spruce stick and twenty-three were spliced with the hard-pine 10 x 10-inch stick, used inside the

building. For all spliced piles the contractor received double pay; this, of course, was more than they were worth as compared with single piles, but as the latter were driven at a loss, it was thought best to be liberal. Nineteen of the piles were cut and furnished by the owner from trees cut on his own estate. These were, of course, green, and were in some cases 2 feet in diameter at the top. The total weight to be supported by these piles was about 1500 tons, making on the average 9 tons per pile, with probably no pile carrying more than 12 or 15 tons. The contractor, though not engaged in the pile-driving business, found that he could drive them cheaper than he could sublet them to other contractors. They were probably

FIG. 4. WALL BEFORE LEVELING.

driven slower, but, no doubt, far better than if by a subcontractor. The force necessary was a foreman, engineer and seven or eight men. The greatest number of piles driven in any week was forty-two. This seems a small number compared with other work, but owing to the presence of the building the moving of the apparatus was slow. From notes taken of the men's time, etc., it would seem that $8 per pile was a fair price for piles driven in good shape under such conditions. The general scheme for the position of piles was 22 inches from the face of the brick walls, but the lower portion of the wall, being built of heavy blocks of granite, often gave trouble by the projections of the latter, and in many cases the piles had to

be moved and almost wedged in between the building stones and driven with a follower to get them down. In this case, 24 or 25 inches from the brick walls would have been cheaper, although taking more iron. As fast as piles were driven they were sawed off and capped. The grade for this cutting was 8.33 above low water, while a few piles, which were to have wooden caps, were cut at grade 7.5. A few idle piles were found in the line of our new ones and were capped and used, although it is doubtful if they were of much benefit.

Inside Piles.—These piles were to be driven inside an existing building and the problem was different. The specifications called for piles made of 10 x 10-inch long-leaf hard-pine timber, in 15-foot sections or lengths, spliced together with iron bands or sleeves, and it was estimated that three lengths at least would be everywhere used, and in the softest places, four. These specifications were followed, and only first-class timber was used. There were about 3000 tons to be borne by the inside walls and ninety-eight piles were used. This made 30 tons at least for the average loading per pile, and in two cases our computations showed that 46 tons would be the actual load. In a few cases, as around piers, 6 tons was the computed load. All piles were numbered, and, after sawing, were tied in. When any inside pile was to be driven the notebook showed the load to be borne, and special pains were taken with the driving in case of the heavily loaded piles. It was the original intention that the inside piles should also be driven with a steam hammer, as it was thought that better work would be done, but the contractor raised the objection that the escaping steam would spoil all the walls of the building. The real reason, without doubt, was that the steam hammer had given him occasional trouble, and, moreover, was exceedingly heavy to move about in this restricted space, besides the care of the escaping steam by a proper exhaust through the windows. We yielded the point, however, on the contractor's guarantee to drive the piles to the same depths with the drop hammer.

Work on the inside piles was begun December 10th, and was finished February 1st; the force of men employed was the same as when working outside. Before work was commenced, the finished work of the lower fireproof floor was taken up, and holes 4 or 5 feet square were cut in the brick arches vertically above the pile, likewise a hole 4 feet square was dug below the cellar floor and excavated to tide water, the pile driver was then set up and the first section driven. When the first 15 feet had been driven, the pile sleeve was placed on the head and pushed into place by the hammer.

Before driving the next stick a saw cut was made around each end, then placed in position on the sleeve below and pushed into place by the hammer. The longest piles were sixty feet and the shortest $37\frac{1}{2}$ feet. In one case an old pile was found in line of our new one and by followers was driven down to a proper grade. Four piles were all that could be driven in one day, under a contract price of $15 each, which entailed a loss to the contractor. From notes of the number of men employed, I have estimated that there was a loss of about $6.50 per pile, making $21 to $22 a fair value for such piles furnished and driven.

The pile splices cost $1.24 apiece, and were furnished by Kendall, of Cambridgeport. Throughout all the pile driving the penetration under the last blows was taken. The method used was to wait until the foreman swore he couldn't drive it any further and then have him take about ten blows. The division of the whole penetration by the number of blows was called the penetration of the last. The smallest penetration of the steam hammer was 0.01 inch, being the average of forty-five blows; the greatest being 1 inch to a blow; a fair average being fifteen blows to an inch. With the drop hammer the smallest penetration was $\frac{1}{4}$ of an inch and the largest $1\frac{1}{4}$ inches; a fair average being $\frac{5}{8}$ to $\frac{3}{4}$ of an inch. Nineteen feet was the maximum drop of the hammer. During the latter part of the inside driving two separate gins and hammers were used; one being used for driving, while the other was being erected for the next pile, and thus the only delay was a few minutes to transfer the lead rope. These inside piles were nearly all driven with a short follower.

In the back part of the building it often took a laborer two days to get a hole cut through the old timber platform below the walls. Outside spliced piles were doweled together with a 2-inch angle iron 8 inches long.

I have previously mentioned the exceptionally heavy loads to be placed on many of the piles. Although we felt safe, we could not help thinking of them, and the owners were induced to purchase for testing purposes an hydraulic jack, of 100 tons capacity, costing $125. This was of Watson-Stillman make, with 4-inch motion and 9-inch base, the pump for cold-weather use taking a mixture of 40 per cent. alcohol and 60 per cent. water. We made six tests with the jack, covering different conditions.

In figuring safe loads, the *Engineering News* formula was used, thus:

$$L = \frac{2\ w\ h}{s + 1} \text{ and } L = \frac{2\ w\ h}{s + 0.1}$$

Where "L" is the load and W the weight of hammer, both in pounds, "h" the fall in feet and "s" the penetration in inches under the last blow, a statement of the various tests which were made follows:

Test No. 1. Pile No. 100.—This was on a green spruce outside pile, 40 feet long, penetration 0.2 of an inch under the steam hammer. The formula gave 10 tons as a safe load, while the actual load was figured as 11 tons. This test began at 11.30 A.M., with a load of 25 tons, and was continued at 12 M., with a load of 30 tons.

From 1.30 P.M. to 3 P.M. the load was 35 tons; from 3 P.M. to 5 P.M. the load was 40 tons, when the test was stopped. During the test no displacement of the pile was noticed.

Test No. 2.—This was in a spliced spruce outside pile, driven with a steam hammer, penetration 0.2 of an inch, and was tested with a load of 50 tons. No settlement occurred.

Test No. 3. Pile No. 127.—This was a spliced spruce outside pile, the lower section being 40 feet and the upper 25 feet long, driven with a steam hammer, with a penetration of 0.2 inches. The jack was placed on top of the granite pile cap, and upon the application of 35 tons the pile cap settled and continued to settle until a load of 60 tons was reached. At the time this test was made there was no concrete about the granite cap, and it was at first thought that the pile might have moved; later, it was decided that this apparent settlement was simply the compression of the fibers of the pile, as in test No. 4.

Test No. 4. Pile No. 122.—This pile was a spliced spruce outside pile, the lower part being 42 feet long and the upper part a hard-pine stick, 10 inches square and 15 feet long, driven with a steam hammer. Computed safe load, 24 tons. The jack was placed on the granite pile cap as before. In this case the cap was surrounded by concrete. The results were as follows:

Load.	Settlement.
20 tons...............	0 inch.
26 "	0 "
40 "	1/32 "
52 "	1/8 "
60 "	3/16 "
77 "	1/4 "

The test was then stopped and load removed. When all but 20 tons had been taken off, the stone cap on the pile head came up, indicating that the pile itself had not moved, but the fibers of the pile were compressed, or that perhaps the joints had closed a trifle.

Test No. 5. Pile No. 12.—A hard-pine pile, 45 feet long, driven with a 2000-pound drop hammer, drop 18 feet and penetra-

tions $\frac{1}{2}$ inch. Safe load, 24 tons; load which piles must carry, 46 tons. In this case the test was 50 tons. No settlement occurred.

Test No. 6. Pile No. 35.—Hard-pine pile, 45 feet long, driven in three sections with 2000-pound hammer, penetration 0.7 inch. Safe loads, 21 tons; load which pile must carry, 46 tons.

Time.	Load.	Settlement.
1.30 P.M.	10 tons.	0 inch.
1.50 "	30 "	0 "
2.00 "	40 "	$\frac{1}{8}$ "
2.15 "	50 "	$\frac{1}{4}$ "
2.40 "	60 "	$\frac{7}{16}$ "

When the load of 60 tons was applied, the loading beam buckled and released the load, after which a net settlement of $\frac{1}{8}$ inch showed.

The results of these tests were very satisfactory, and indicated the piles were safe under any load we expected to put upon them.

Sawing Off Piles.—The contract price for sawing off piles was 20 cents. It cost the contractor about 50 or 60 cents. This was due to the small space in which the men worked, the narrowness of the trenches, the fact that many piles were driven hard up to the walls, and also that the men worked part of the time in the water.

During the time occupied by the driving of the outside piles, the largest settlement noticed by telltales was $\frac{6}{100}$ of a foot in the back end of the building.

On February 1st, or after all piles were driven, the largest settlement on the back was $\frac{9}{100}$ of a foot; the largest settlement on the inside was $\frac{7}{100}$ of a foot.

Granite Caps.—Every pile was capped with granite blocks with their tops and bottoms medium pointed. The depth varied from 8 to 28 inches, with $\frac{1}{4}$ inch allowance for joints. The reason for the variations in depth was that the iron beams above were of varying sizes, and it was necessary to set the tops of the middle tier of beams at the same level. Practically, all the stones were 2 feet square, and prices on furnishing and delivering these stones varied from $525 to $675. The contract was awarded to Field & Wilde, of Quincy, for the former sum. This price was later reduced to $500, provided the engineers would not be too particular about the "looks" of the stone. These stones, where possible, were bonded to existing masonry by concrete. For the proper bedding for the iron beams it was necessary that the tops of the stones should be level. This was not always the case, and a stone mason often had to point a trough through the top for a width equal to the flanges of the beams. The cost of such pointing was $30. This, in the end, was cheaper than using a more finished quality of stone. These stones were easily

handled by two men with a bar, and were lowered into place with a differential pulley. As fast as the stones were set, the piles underneath were located on the stones and marked with a cross of black paint. These stones when set were all bedded in concrete, and where they were near together the space between the edges were also filled.

ITEMIZED COST OF CAPPING PILES.

258 stone caps	$500.00
265 piles sawed, at 20 cents	53.00
Dressing stone	35.00
Chain falls	21.00
Laborers	168.40
Mason	96.39
	$873.79

Or about $3.40 per pile.

Exclusive of pumping and concreting, a mason and tender could lay fourteen stones per eight-hour day.

Concrete.—The gravel concrete used for this work was mixed 5:3:1. The first cement used was Krouse's. This was very slow setting, and we soon changed to Atlas. The concrete was wheeled out on stagings and allowed to be dropped about 10 feet into position. Gravel and sand for this work cost $1.30 per cubic yard, delivered.

Steel Work.—The total weight of steel beams for which bids were asked was 118,698 pounds, nearly 60 tons. Specifications were sent to ten representative companies, and the contract awarded to the Phœnix Iron Company, for 1.675 cents per pound, f. o. b. Huntington Avenue, Boston, from which yard they were teamed by the R. S. Brine Company for 59 cents per ton.

All iron beams were painted with two coats of red lead and were perfectly plain, without punching or drilling. There were three tiers of beams:

First. The girders forming the lowest course and resting directly along the pile caps. These acted as continuous girders and their size was not figured. These, in general, were made 12 inches deep, which seemed reasonably safe, especially as each beam was bedded in a 12-inch strip of concrete. Similar beams on the inside could be computed as a simple beam with one or more concentrated loads. These beams varied from 12 to 20 inches in depth.

Second. The crossbeams supported by the former and extending from the outside through the walls to the inside. These beams were all computed, and for the outside walls made 15 inches. Weights, 42, 50 and 60 pounds. These beams were likewise bedded

in the concrete. At the main corners of the buildings these beams were laid double or even triple, with the edges of the flanges at least ½ inch apart, to facilitate the grouting.

Third. The longitudinal beams resting on the crossbeams were laid in pairs, the extreme edges of the flanges being flush with the edges of the 16-inch wall, the space between them being filled with concrete. These were all light, 8 or 10-inch beams, and directly supported the wall above.

The first beam was set January 15th and the last not until some time in March.

The steel beams began to arrive about the middle of January, and the work of setting them commenced at once. This was the building mover's contract. The price for this was $500. This was done at a profit to the contractor, as, taken in conjunction with his other work, it probably cost him from 50 to 75 cents apiece, or not more than $150 for the whole. The work of bedding them was done by the owner. The first beam placed was on January 15th, after one-half of the inside piles had been driven. These first beams were, of course, the long one upon the pile caps. These were easily handled, the only particular work about them being the proper placing. The axis line of the beam was made to fit an average line through the centers of the piles. After these beams were in place, the position of the crossbeams was marked on the top flange of the former with black paint. At these points was also marked the number of the beam. The setting of the crossbeams was more difficult. Holes were cut through the wall wide enough to admit of their passage. They were then bedded in cement and surrounded by concrete. Before many of these were placed the contractor had started to build his blocking; where this was done in advance of the beam laying, holes were left between the crib work at all places where the crossbeams were to go. This setting of the top beams was not done until after the building was loaded. They were then run in between the bilge ways and easily placed.

During the progress of placing the steel we found the original iron support work constantly in the way. Where this was the case it was cut off. In most cases this did not weaken the existing supports. The cost of cutting this old iron was $206. A great many of these odds and ends of beams were used in place of new ones ordered for our work, and their value more than paid for what labor was done upon them; in fact, I may say where an old beam could be used and was available a new beam was not used, and, after completion of the work, the owners had for sale several tons of unused steel. It may be thought that the engineers could have fore-

seen the fact that the old beams could have been used, but it must be remembered that they were all buried several feet under the ground and their reliability was uncertain. They were carrying, or supposed to be carrying, part of the wall, and it might be unsafe to cut them out at the time they might be needed.

The loading of the building was begun January 28th, and was finished ready to raise January 19th. This was done in the same general manner as in other buildings, and the process of raising was immediately commenced, and lasted perhaps a week or ten days. There were in use between 700 and 800 jacks, each of 4 or 5 tons capacity. The maximum force used on this part of the work was about sixteen men. Each man was given charge of a certain number of jacks. At the sound of a whistle each one was given a quarter turn. The general appearance of the wall and blocking was noted, and, if all was well, this process was continued until the desired lift had been obtained. Levels were taken every day while the raising continued, the bottom flanges of the beams in the first floor being taken as a guide. Either lanterns or bicycle lamps were necessary for leveling done at this time in the cellar. In all cases the instrument was perched upon the blocking and the leveling rod inverted.

As fast as certain sections of the first floor were leveled the walls were pinned off, and, four or five days afterward, the needles were withdrawn. It is interesting to note that the heavy middle wall was the cause of much of the original settlement, and this was the only portion which gave any trouble in raising. Among other troublesome things was the necessary work around the boiler, which was accomplished without removing it from the room.

After the raising was complete, the offsets to the building were taken from the original base line. These measurements showed that the front wall is almost exactly plumb. The back wall, which was in the worst condition, is all right in spots and in places 2 inches out. The side walls are in places all right, and at the worst spots are but 2 inches out of plumb. Portions of the wall with big cracks were rebuilt.

The work was completed without injury to the workmen from falling walls and other débris, and our portion of the work was finished in April, the total cost of work under our direct supervision being about $20,000.

A great deal of credit is due to Isaac Blair & Co. for the careful and workmanlike way in which they fulfilled their contract.

It is interesting to note that more lineal feet of piles were used in the original foundations of this building than was necessary to properly carry it.

The fact most apparent from this work is, perhaps, that such piles will stand an excessive load of 35 to 50 tons if well driven and if the spacing is say 4-foot minimum.

DISCUSSION.

Mr. Henry F. Bryant.—The preceding paper has set forth the facts accurately and in considerable detail. I can add but little, but will state what seem to be the main points of interest.

This building was in such bad shape that only a few of its apartments had been occupied, and those had been vacated by order of the public officials, who felt that collapse was sufficiently near to require that the street in front should be fenced off for half its width, to prevent injury from falling walls.

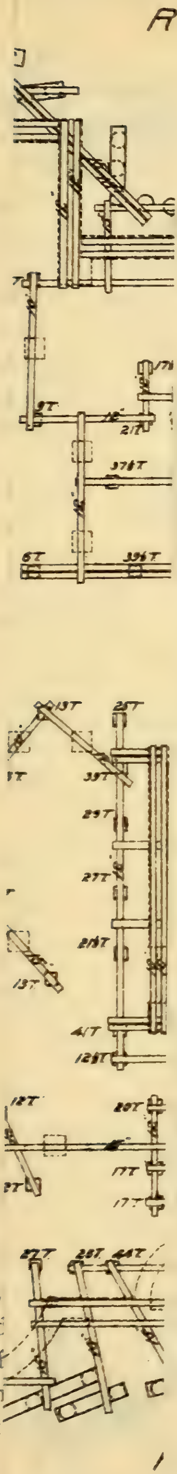
This serious condition was unquestionably due to the use of too short piles, penetrating only a foot or two, if at all, into the soft sand below the peat. It is difficult to understand how architect or builder could permit such construction, but it was apparently a case where the architect, in making his contracts, had not sufficiently informed himself of the conditions to be met and had failed to exercise proper supervision of construction. The builder failed to properly watch the pile driver, who, under a lump contract, cared nothing for the quality of his work.

While in this serious condition, with the property in the hands of the mortgagee under foreclosure, and for sale for but little more than the value of the land plus the building materials, the present owners took advice from many sources regarding the possibility of repairs. Practically all advice was unfavorable except ours, and as such advice was what they desired to get, they naturally accepted it, especially as it confirmed their own opinion as experienced and conservative men.

It took some courage to do this and to clear off all the labor liens and other charges, which amounted to a considerable sum.

That the undertaking was a troublesome and dangerous one can be inferred from the statement of the contractors, Isaac Blair & Co., who have done most of Boston's difficult building moving and like work, that it was the toughest proposition they ever met.

There was a strong temptation to do this work differently; that is, to move the building to one side, put in new foundations and replace it. The expense would have been about the same but the details much simpler. What was feared was that it was impossible to support such a heavy structure on the existing filling underlaid by peat without constant settlements and cracking of walls.



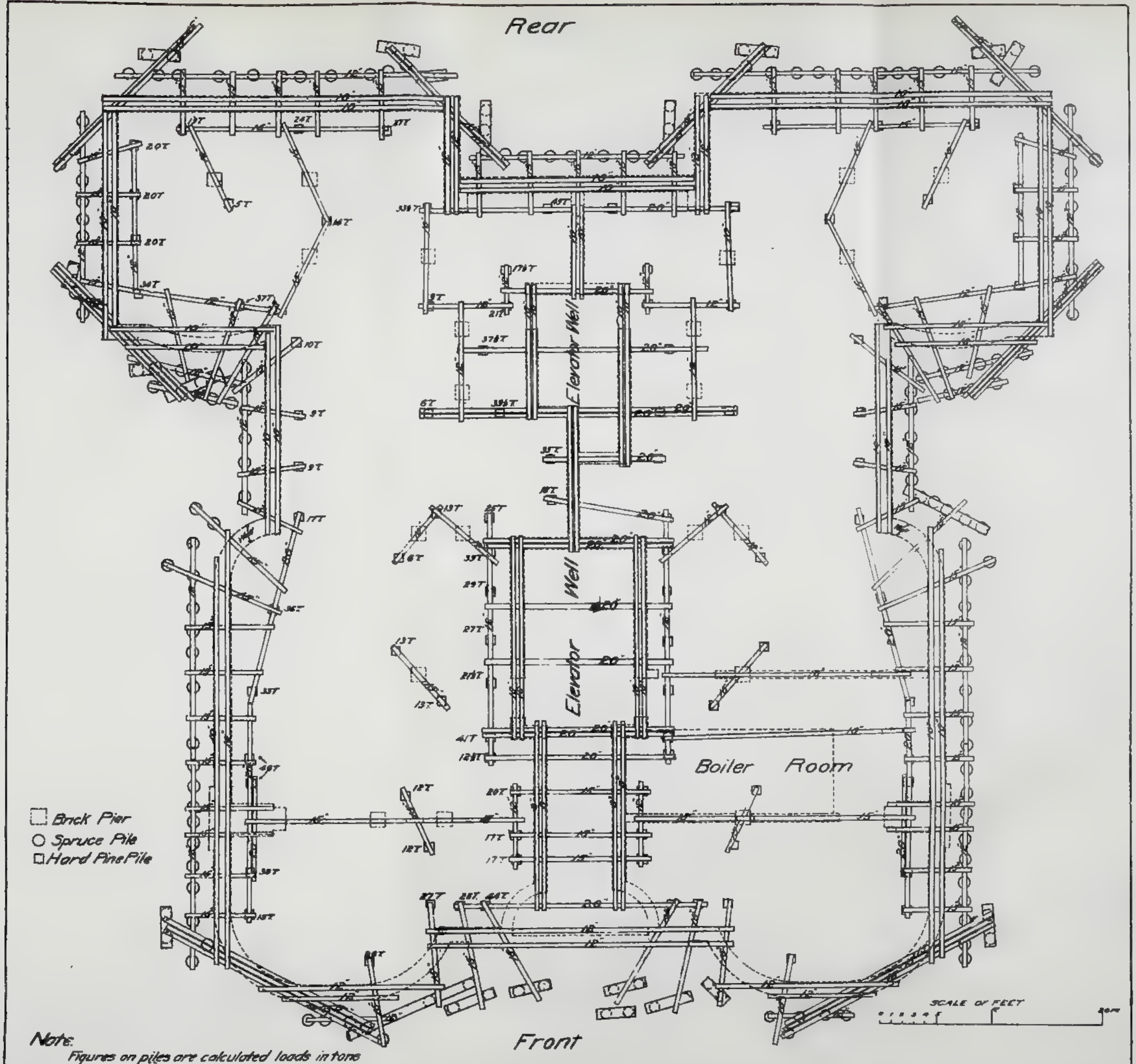


FIG. 2. PLAN OF FOUNDATIONS OF HOTEL WOLLATON, BROOKLINE, MASS.

AN C

I must say that our later work indicated much greater supporting power in the peat than was anticipated, although at no time was the whole weight on the blockings resting on fill alone.

The only uncommon features of the work were the interior heavily loaded spliced piles and the use of iron below water level in close proximity to a peat formed in brackish water.

Spliced piles must, of course, be laterally weaker than single sticks, and we endeavored to place the splices within a few feet of solid earth, either original or filled. By using squared hard-pine timber, we failed to note any evidences of anything but vertical driving in a straight line, or of the displacement of one stick from another.

The tests, which might be criticized as being only of short duration, failed to show any evidence of settlement or other motion of the interior piles, and that under very unusual loads.

We were led to attempt this loading from the collection and study of the reports of a great many from all over this country and from abroad. It became evident to us that, given a reasonably resistant soil with no underlying soft clay, loads of 75 to 100 tons could be properly placed on good sturdy spruce or Norway pine piles with proper penetration, always provided they were not placed too near to each other, and thus exceed the compressive strength of the soil.

I am sorry we were unable to get more than 70 tons on any one pile, but the building was not heavy enough or the steel beams used were too weak for anything more.

For a similar building alongside, I should be willing to drive piles to carry 20 to 25 tons, and in so doing to save money over driving shallower piles at 8 or 10 tons each.

It has been asked how long the iron beams would last under the conditions now existing. This is not easily answered, as much depends on the quality of the peat, the rise and fall of ground water and the care with which they were painted, first with red lead and then with neat Portland cement grout, and also on the porosity of the surrounding concrete.

We attempted to have the coating, both of paint and cement, well put on and free from cracks or scratches, and the concrete was quite carefully laid to absolutely surround the beam. I do not think that the ground water is likely to fluctuate much from grade — 10, or that it will contain the salts which do so much damage to steel in ordinary peat. For instance, in some of the lower levels of Boston, Brookline and probably many other

towns, lead service pipes are the only ones to be used with safety, wrought-iron and, to an extent, cast-iron disappearing rapidly.

In my judgment, the iron beams will last long enough to keep the maximum fiber stress within the elastic limit for from fifty to seventy-five years.

Moreover, it will be noted from the section, that the concrete is in most cases so disposed as to serve either as a beam or an arch between the piles and should, with the help of the old foundations, support the building indefinitely.

At this time the building has been repaired some few years, and, so far as we can learn, has shown no sign of weakness at any point.

CONSTRUCTION OF A SCHERZER DOUBLE-ROLLER LIFT BRIDGE AT MIDDLE SENECA STREET, CLEVELAND, OHIO.

By William J. Carter, Chief Engineer, City of Cleveland, Member of the Civil Engineers' Club of Cleveland.

[Read before the Club, September 8, 1903.*]

Without attempting to describe the preliminary work leading up to the adoption of a double-roller lift bridge at Middle Seneca Street, I will give a brief account of the difficulties encountered in building the bridge, principally the substructure.

On February 4, 1901, a contract was let to F. E. Gribben for the construction of the substructure of Middle Seneca Street Bridge. The Scherzer plans called for submerged counterweight pits, and indicated that the substructure was to be built in a cofferdam constructed of a single row of Wakefield triple-lap sheath piling.

After taking out the old abutments and center pier, the contractor refused to proceed unless permitted to build a double cofferdam with a clay puddle wall. This permission was refused, and the city proceeded with the work under a contract with G. Wm. Doerzbach.

At this stage the United States Government insisted that the city must secure permission from the Secretary of War for the construction of the bridge. This matter was taken up officially, and it resulted in the Government changing the location by moving the south abutment twenty-five feet into the river and setting the north abutment back twenty-five feet. This change has not been a beneficial one, as large vessels, going up stream against a very slight current, cannot avoid bringing up against the south abutment.

The foreman, in charge of the work for Mr. Doerzbach, submitted his plans for the cofferdam consisting of a single row of nine-inch Wakefield sheath piling. He also proposed to arrange a system of truss bracing that would permit the erection of a steel pit lining without having to take out cross-braces.

The borings taken showed a layer of clay five feet thick at the site of the south cofferdam, and it was decided to drive sheathing thirty-five feet long that would penetrate this layer its entire depth. The clay was also shown by the borings at about the same elevation for the north side. The work of driving the sheathing progressed without any noteworthy incident. The contractor, however, used

* Manuscript received February 27, 1904.—Secretary, Ass'n of Eng. Socs.

a peculiar method of closing his work; he would start sheathing about fourteen feet in advance of his finished work and drive from this point toward his finished work, thus making it necessary to use a closure.

This method appeared to work out first-class, but later developments showed that a worse method could not have been used, as instead of the two adjacent sheath pilings going down in the same vertical plane, invariably one was inclined at a different angle from the other, so that the closure instead of closing up the gap sometimes opened a much larger one.

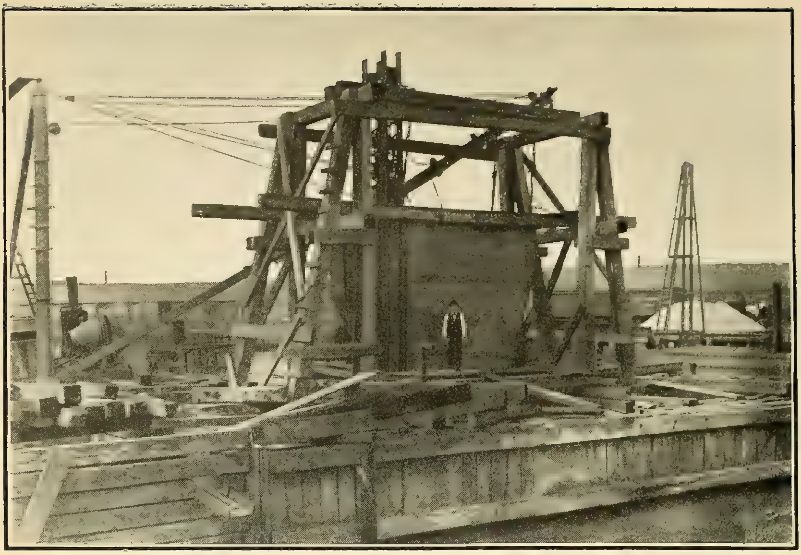
The cofferdams, as outlined, were completed during February, 1902, and an attempt was made to pump out the south cofferdam in March. After pumping two hours with a six-inch and an eight-inch centrifugal pump and only lowering the water one and one-half feet, it became evident that something was wrong. An examination of the dam was made by the diver and a serious leak found, one very large one in the rear where one of the aforesaid closures had been made. This opening was so large that the diver could walk through it.

In order to overcome this break a box was built around the effected portion of the dam and filled with concrete. The smaller leaks were calked up and pumps again started.

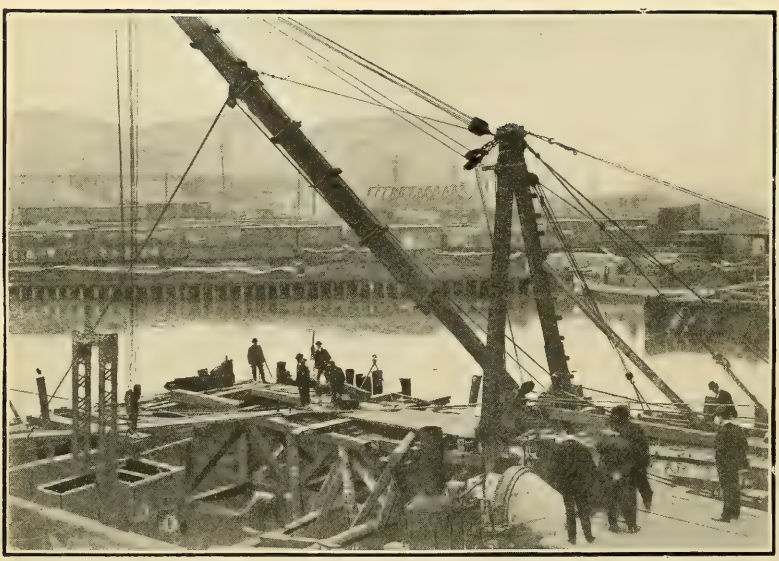
The water, however, broke through the box apparently coming under the bottom. At this time some additional borings were made to see whether we had the clay penetration figured upon and it was found that the clay was about seven feet lower than originally supposed. So it was necessary to surround the first cofferdam with sheathing forty-five feet in length. This was done, and in order to transmit the water pressure to the inner bracing, the space between the two sets of sheathing was filled with concrete. In driving this outer sheathing at a few points around the dam, obstructions were encountered, that seemed to be in the nature of logs, some of them at a depth of about fourteen feet below the river bottom.

On June 4th, the pumps were again started and the water lowered about eight feet, when the second set of bracing was put in place. The water was then lowered thirteen feet, when a bad hole opened up in the northwest corner at a point where a submerged log interfered with the driving of the outer sheathing. This break was so serious that our pumps were unable to cope with it.

The formation above the clay was coarse sand and gravel for several feet; above this, quicksand and then the river silt. It was thought that, by injecting cement grout, this stratum of



Pit Lining, South Abutment, Ready to Lower.



Setting Pit Lining, North Abutment.

South Arm Erected.

gravel and sand might be solidified around the points where submerged logs had been encountered in driving the outer sheathing.

Some inch and a quarter piping was secured and driven down until the clay stratum was penetrated. A plug in the end of the pipe served as a shoe for the pipe and afterward was driven out with a rod. The pipe was then raised about six inches at a time, the cement grout being pumped in with a small force pump. This method of injecting grout was used at each point where we had encountered submerged logs. Pumping was again attempted, but satisfactory progress was not made, so we decided to deposit a five-foot layer of concrete over the entire bottom with the exception of the spaces occupied by counterweight pits, these spaces to have the concrete excluded by building a form around them. This layer of concrete was deposited through the water by means of a spout, the concrete being mixed in a Smith concrete mixer, with sufficient water to make a good mortar, and handled by means of a wheelbarrow to the spouts, the bottom of the spout being within a foot of the foundation. The spout was gradually raised as the material filled up. The five-foot thickness was made up in three layers, the surface being regulated by means of soundings so that the layers were comparatively level. Grout was injected into the spaces to be occupied by the counterweights. After the cement had set for five days, the pumps were started and the surface of the concrete uncovered.

The original leak in the rear of the cofferdam now made its appearance through the spaces left for the counterweights. After several ineffectual attempts to stop this leak it was decided to build the steel pit linings above their respective pits and lower them into position, building concrete around them, using the diver to deposit the same, and ram the concrete into place.

The bridge company objected to using this method of placing the pit linings for fear that, on account of the small clearance for the counterweights, it would be impossible to secure good enough alignment, but after having been assured that the city would assume all risks they proceeded and had the pits lowered into place, when they were concreted. After five days the pit was pumped out without any further trouble and kept clear by means of a four-inch pulsometer.

In clearing up the counterweight pits prior to lowering the steel linings in place, some of the effects of the injected grout appeared. It was necessary to excavate about two feet in each pit to get the proper amount of concrete deposited beneath the pit linings. In making this excavation layers of cement rock were en-

countered that had to be blasted to remove the same. These layers were just as natural as the sand formation showing that the grout had penetrated to good effect. Whether this was the case in all points, I am unable to state.

The north cofferdam, being nearer inshore, made it possible to surround the front and two sides with an outer row of sheathing forty-five feet in length, and not drive any in the rear. An examination of this sheathing by the diver before the pumps were started showed several places where breaks had occurred, but none of these breaks were at a point over six feet above the river bottom. It was thought that if clay was deposited along the outer face and two sides of sufficient depth to extend same above this six-foot point that all of these openings could be effectually stopped, and this was done.

The six-inch and eight-inch centrifugal pumps did not work very satisfactorily in pumping out the south cofferdam after they had to work under head of from twelve to fourteen feet. Just about the time the pumps succeeded in lowering the water to the concrete that had been previously deposited, the large pump would lose suction, sometimes taking from one-half to three-quarters of an hour before the same could be put in operation, permitting the water to rise a couple of feet all over the cofferdam.

For this reason I decided to use a ten-inch submerged centrifugal pump on the north side of the river. This pump was mounted in a framework made up of four 6 x 6 timbers, securely braced and of sufficient length to reach the bottom of the pit when excavated.

This pump was lowered into position and operated with a 30-horse-power horizontal engine. Our first attempt to pump out the north dam was successful with such a pump in about two hours. One leak developed in the west side of the dam that seemed to indicate trouble, but a couple of scow loads of clay dumped opposite this point effectually stopped the leak. There was so little leakage after this that it was impossible to operate the ten-inch pump, so the pit was kept free by means of the six-inch Nye pump.

The work of clearing out this pit and putting in the concrete progressed without any unusual difficulties.

The pit linings on this side of the river were built on the dock and lowered bodily into place, this being made possible on account of having used truss bracing, leaving a clear space for the pits.

The superstructure was designed for a one-hundred-and-twenty-foot clear channel, the truss design giving somewhat the appearance of an arch by using the curved bottom chord, the top chord meeting the same at the center of the river. The chord of one arm

was open and that of the opposite arm was finished wedge shape, the wedge entering the opposite chord, when the two arms are lowered into place. The counterweight is placed in the end triangular panel, the castings being bolted on either side of a web plate. These counterweights, when the bridge is open, rotate into the pit, the bottom of the weight at the lowest point being about eighteen feet below the surface of the river.

No difficulty has been encountered in operating the bridge, even if pit linings are filled with water.

The bridge is operated by means of two 25-horse-power electric motors on each arm. It takes from 78 to 84 amperes to raise the arm and from 45 to 60 to lower it; the bridge can be opened in one minute and closed in forty-six seconds. The controllers are similar to those used on the street cars. Provision has been made so that one operator can operate both arms; this is only to be done in case of an emergency, each arm being operated independently.

A system of signal lights in the operator's house indicates the exact condition in which the bridge is placed. The first notch operates the breaks and pulls out the tail locks. The second notch starts the bridge in motion.

When the bridge has been lowered, the proper connections made and everything locked, the signal lights go out. Should any one of the operations be neglected, the lamps continue to burn.

After many little vexatious delays, this work having extended over a period of two years, it was very gratifying to lower the two arms and have them fit perfectly.

The superstructure weighs 416.28 tons, exclusive of counterweights, the counterweights amounting to 227.31 tons.

The lumber in flooring, 40,000 feet B.M.

I believe one thing that has been brought out with more force than anything else during the construction of this bridge has been not to build a bridge with submerged counterweights. About all the trouble that was encountered could be attributed in some way or other to these submerged counterweight pits.

The bridge is of the Scherzer design. It cost, including a $5000 royalty, $74,277.99 for substructure and $63,096.65 for superstructure.

This bridge has been in service since June 25th and works well.

THE LACKAWANNA AND WYOMING VALLEY RAILROAD.

By George B. Francis, Member of the Boston Society of Civil Engineers.

[Read before the Society, January 14, 1904.*]

This project was conceived in 1900 by parties having interests in the northern anthracite coal region, who believed that there was need of better freight and passenger service for the local requirements, and that a first-class interurban electric railroad from one end to the other of this coal field would prove to be a good investment.

The Lackawanna Valley, in which flows the Lackawanna River, a branch of the Susquehanna River, is a continuation of the Wyoming Valley, in which flows the Susquehanna River, the latter river breaking through the northern boundary ridge of the valley at Pittston, a point near the center of the coal measures.

These valleys are in the Alleghany Mountain region of the northern part of the State of Pennsylvania.

The three coal fields known as the southern, middle and northern anthracite coal fields of Pennsylvania are the only anthracite coal fields deserving of mention in the United States, and the demand for this coal comes from all points of the compass. The area of these fields is the equivalent of a tract of land twenty-two miles square. These coal measures were once horizontal and bituminous, but the volatile elements of sootiness and gas have been driven off under the great heat and pressure to which they were subjected when the Alleghany Mountains were uplifted.

This coal was discovered between 1770 and 1790, at the time of the Revolutionary War, by a party of hunters, but was not mined until 1807, and mining was not developed as a trade until 1820.

The northern coal field extends from Carbondale, on the northeast, to Nanticoke, on the southwest, a distance of about fifty miles. At Carbondale, the coal lies near the surface, and at Nanticoke, in some veins, as deep as eighteen hundred feet, and there is yet much coal to be mined.

Scranton and Wilkesbarre lie twenty miles apart, near the center of the coal fields. These cities, together with the intermediate territory, provide a population of upward of 200,000 people adjacent to the railroad to be described.

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* Manuscript received March 3, 1904.—Secretary, Ass'n of Eng. Socs.

Scranton Terminal. Loop and Shelter.

Track View. Meadow Brook Valley.

Owing to the coal transportation, several railroads have been built to and through these valleys, as follows:

The Lackawanna Railroad,*
The Lehigh Valley Railroad,* †
The Erie Railroad,‡
The Delaware and Hudson Railroad,
The Ontario and Western Railroad,
The Central Railroad of New Jersey,
The Pennsylvania Railroad.

The street railways in the valley also extend from Carbondale to Nanticoke.

This explanation of the railroads and coal measures is necessary as a preliminary to show why the Lackawanna and Wyoming Valley Railroad was so expensive to build and why it required so many different kinds of structures.

The railroad now to be described, which has been built under steam-railroad charter and which is now being operated, extends from Wilkesbarre to Scranton, a distance of about twenty miles.

It is a standard-gauge, double-track, rock-ballasted, third-rail electric road on a private right of way throughout its length, laid with 90-pound rail.

It was opened for business from Scranton to Pittston in May, 1903; from Pittston to Hancock in September, 1903, and from Hancock to Wilkesbarre in December, 1903. Later on, it is expected that the road will be extended to Carbondale.

The railroad enters Scranton by a temporary location, known as the Erie cut-off, with steep grades (4 per cent.) over a hill that is to be pierced by a double-track tunnel.

Except on the temporary cut-off above noted, and at the terminal loops in Scranton and Wilkesbarre, used only for passenger service, the alignment is within the limits of good practice for steam railroads of the first class.

With the exception of the temporary cut-off above noted, the profile of grade line of the track is as good as those of the steam railroads in the same mountain region, the maximum rate being 2 per cent.

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* The Lehigh Valley and the Lackawanna are trunk-line railroads between New York City and the West, passing through this coal region.

† The Lehigh Valley Railroad controls the Pennsylvania and New York Canal and Railroad.

‡ The Erie Railroad controls the New York, Susquehanna and Western Railroad, the Erie and Wyoming Valley Railroad and the Wilkesbarre and Eastern Railroad.

The track, including rails, ties, ballast and switches, is of first-class standard steam-railroad construction; in fact, equal to the best existing construction.

In addition to the passenger traffic, it is intended that the road shall serve as a freight road for the interchange of bulk freight between the steam roads entering one end of the valley and not reaching the other, of which there are several. A local freight service has also been inaugurated.

Beginning with the terminal station at Wilkesbarre, the physical characteristics are described as follows:

The Wilkesbarre Terminal is in the heart of the city, on the opposite side of North Market Street from the Union Station of the various steam roads. Here is a capacious terminal passenger-station building, costing in the neighborhood of $50,000; also freight house and freight yards. The tracks lead out of the city by way of the old Pennsylvania and New York Canal and Railroad Company right of way, purchased and leased from the Lehigh Valley Railroad, to the bank of the Susquehanna River. Along the bank of this river are constructed three timber cribs, about 30 feet high and aggregating 1800 feet in length.*

Mill Creek Bridge, at the city line, has been built in several spans, supported on concrete masonry, according to the terms of the right-of-way agreement. The tracks then pass under a bridge span of the Wilkesbarre and Eastern Railroad, which bridge span has been entirely rebuilt to give sufficient head room.

Near the New Prospect Breaker, a viaduct has been constructed, 554 feet in length and about 800 tons weight, to carry the road over the two Harvey's Lake Branch tracks, the four main tracks of the Lehigh Valley Railroad, the mine tracks of the Lehigh Valley Coal Company, the highway upon which is the track of the Wilkesbarre and Wyoming Valley Traction Company, and the three tracks of the Central Railroad of New Jersey.

At this point a mine-opening bridge has been built for the relocated highway. Various retaining walls and pipe subways have been built here; also a pump house and gas-tank building have been relocated and built.

Several bridges have been built for the crossing of highways in the next few miles, as follows:

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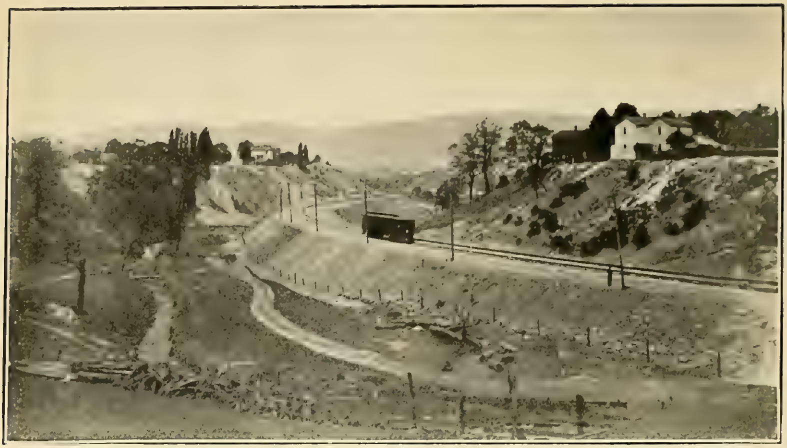
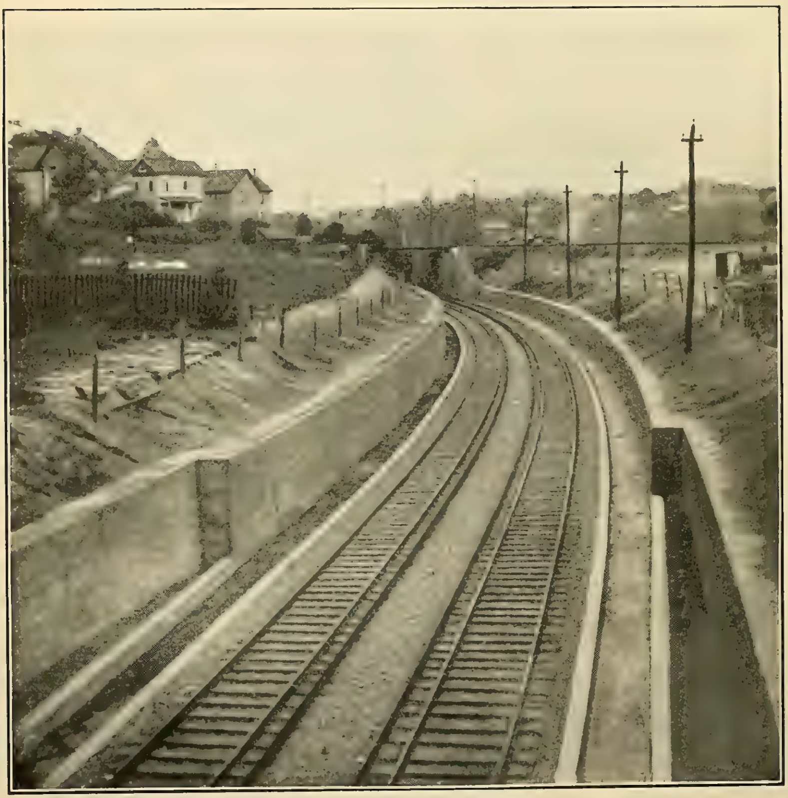
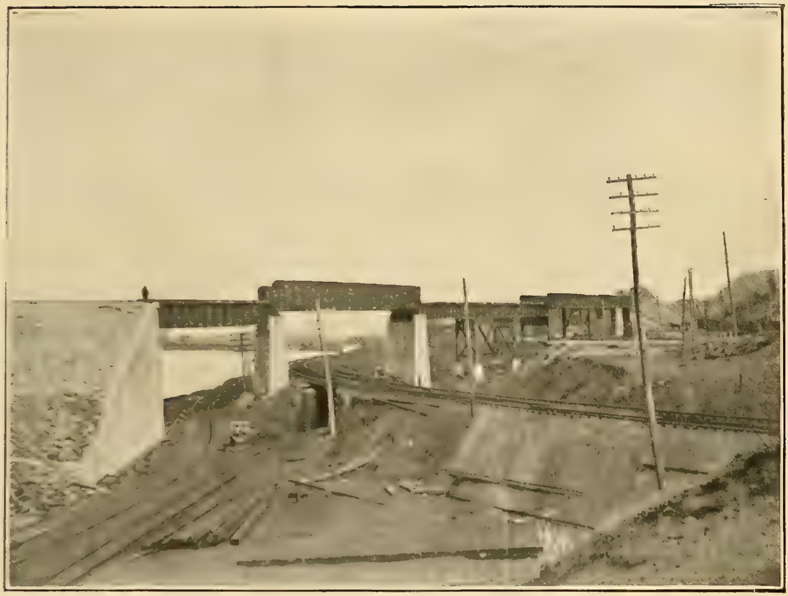
* Described and illustrated by the author, in "Timber Crib Construction," Journal of the Association of Engineering Societies, vol. xxxii, No. 2, February, 1904.



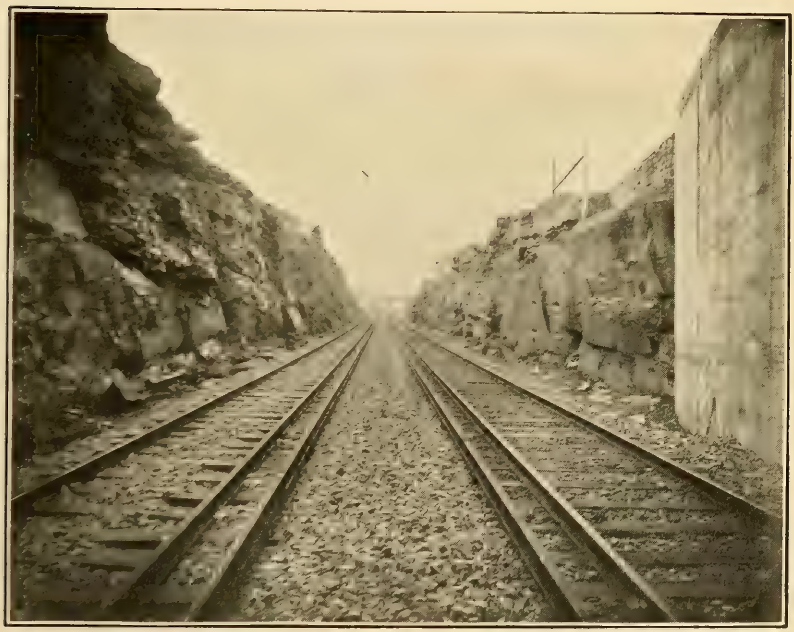
Track View. Pittston Ravine.



Nolan Street Retaining Walls. Erie Railroad Bridge in Distance.



Prospect Viaduct.



Rock Cut, Moosic.

Port Bowkley Road,
Hancock Avenue,
Haley's Road,
Saylor Road,
Inkerman Road.

At Swoyer's Hill cut it has been necessary to build timber brattice work on both sides of the cut for 900 feet in length, to keep the blue clay from sliding on to the track. The timber struts extend under the tracks from side to side each 5 feet.

A bridge has been constructed over the Erie Railroad track, as well as other bridges for Erie Railroad mine tracks, just westerly of Pittston.

In entering Pittston from the west it has been necessary to build retaining walls of considerable length, and to build a bridge at Nolan Street, a bridge for the Erie Railroad and a bridge for Plank Street to pass over the railroad.

In the city of Pittston a three-track through plate-girder bridge of about 90-foot span has been built over Main Street.

Another three-track bridge has been built over Railroad Street.

Both a passenger and a freight station have been constructed at Pittston.

A large culvert was built in the ravine going out of Pittston on the north.

Heavy retaining walls were built between Broad and Williams Streets, Pittston; also a bridge over the tracks for both these streets, as well as a bridge for the Erie Railroad over the tracks near Broad Street.

At Heidelberg, a bridge was built for the railroad over the street and the street railway.

A viaduct about 600 feet long was built at Avoca over the tracks of the Lehigh Valley Railroad and the Delaware and Hudson Railroad, a highway and a street railroad. This viaduct was for the purpose of crossing from one side of the ravine to the other. It contains about 1300 tons of steel.

Another bridge was built over Plane Street, Avoca. Near this place, as well as at several other places, it was necessary to go into the mine workings and build masonry to support the abutments of bridges where the roof of the mines was so thin that there was danger of its caving in.

At Moosic, the tracks pass under another bridge (which was built to carry the Erie Railroad) in a deep rock-cut.

At Spring Brook, Moosic, two bridges have been built to carry the tracks over a highway, a branch railroad and Spring Brook.

The railroad then passes through Meadow Brook Valley on easy grades.

The passenger station at Scranton is a substantial brick building, which has cost about $50,000. It contains the main offices of the company and is located near the center of Scranton. The terminal site contains about 100 acres and was formerly the location of the north works of the Scranton Iron and Steel Company, now removed to Buffalo.

The passenger station has a loop track of 60 feet radius, the same as at Wilkesbarre.

The freight house at Scranton is a substantial building, so arranged that it can be enlarged as needed.

The problem of securing terminal lands in the heart of Scranton, Pittston and Wilkesbarre, as well as securing right of way through the coal lands and workings, was a stupendous one, and only through the utmost patience and perseverance was it accomplished.

In Scranton, it was solved through the moving of the Lackawanna Iron and Steel Company to Buffalo, which threw a large area of land into the market.

In Pittston, a long strip of land through the center of the city was secured from the Pennsylvania Coal Company, but before the transaction was completed the coal company came under the control of the Erie Railroad Company, and it was many months before the stipulations of construction, etc., could be reduced to an agreement and the agreement signed.

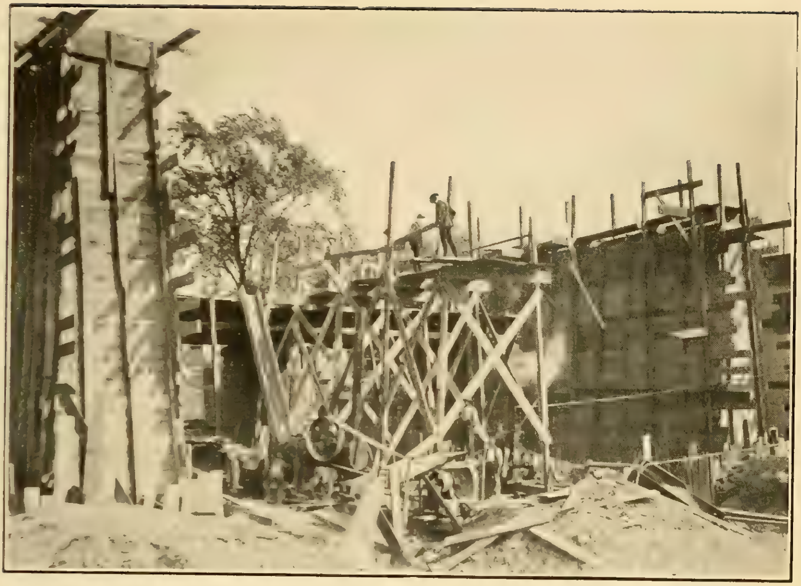
In the approach to Wilkesbarre, the right of way traversed lands of individuals who had leased surface and mining rights to the Wyoming Coal Company, Lehigh Valley Coal Company, Lehigh Valley Railroad Company, Central Railroad of New Jersey and the Pennsylvania and New York Canal and Railroad Company, as well as lands owned by these various companies. The right of way also interfered with streets, city railroad tracks, culm banks, mine workings, gas works, pump houses, etc.; but, after hard labor on joint surveys, consultations, tentative agreement papers and infinite patience by all concerned, the vexatious problems were solved, one after another, and the road built.

The terminal site in Wilkesbarre involved the purchase of several acres of improved property and the exercise of much ingenuity and tact to secure the willingness of the owners to part with their property and at the same time avoid being compelled to pay extremely high rates.

At various other places much difficulty was experienced in

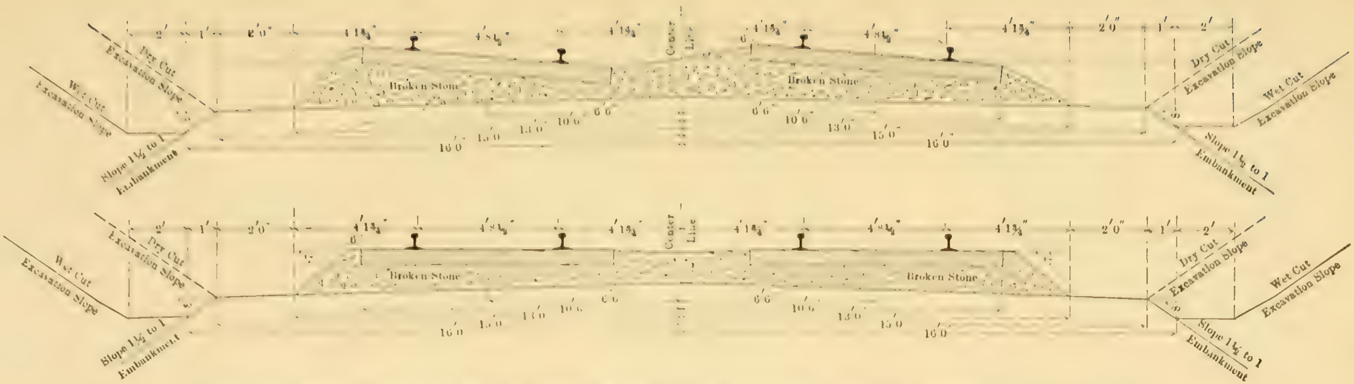
Heidelberg Bridge.

Brattice Work. Swoyer's Hill Cut.

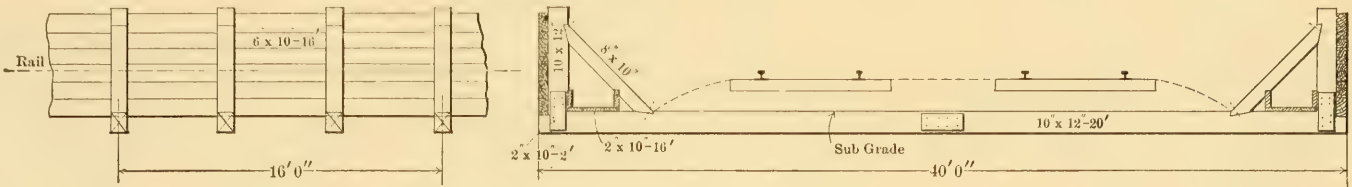


Mill Creek Bridge Showing Forms for Concrete.

Mill Creek Bridge, Abutments and Piers; Showing Concrete Stripped of Forms.



STANDARD TRACK SECTIONS FOR DOUBLE TRACK, LACKAWANNA AND WYOMING VALLEY RAILROAD.



BRATTICE-WORK CRADLE, SWOYER HILL CUT.

BILL OF MATERIAL FOR 16-FOOT PANEL.

	Ft. BM.		Ft. BM.
6 pieces sills, 10 x 12, 20 feet	1200	10 pieces flume, 2 x 10, 16 feet	267
6 " posts, 10 x 12, 5 feet 4 inches	320	9 " plasters, 2 x 10, 2 feet	30
3 " braces, 8 x 10, 12 feet	240	24 boat spikes, ½ x 8.	3017
12 " lagging, 6 x 10, 16 feet	960	32 20d nails.	

securing right of way, and resort was had many times to condemnation proceedings.

With the exception of the freight and passenger stations at Wilkesbarre, Hancock, Pittston and Scranton, the stopping points consist of platforms on each side of the tracks, with small shelters. There are no ticket agents excepting at the four places named above.

As a rule, the stopping places are at under or over-crossings, and the crossing of tracks at grade and the breaking of the third rail are avoided. There are, however, a few exceptions to this rule.

Nearly all the masonry required for retaining walls, bridge abutments and culverts has been constructed of Portland cement concrete, and the following is extracted from the specifications for such work:

EXTRACTS FROM CONCRETE SPECIFICATION.

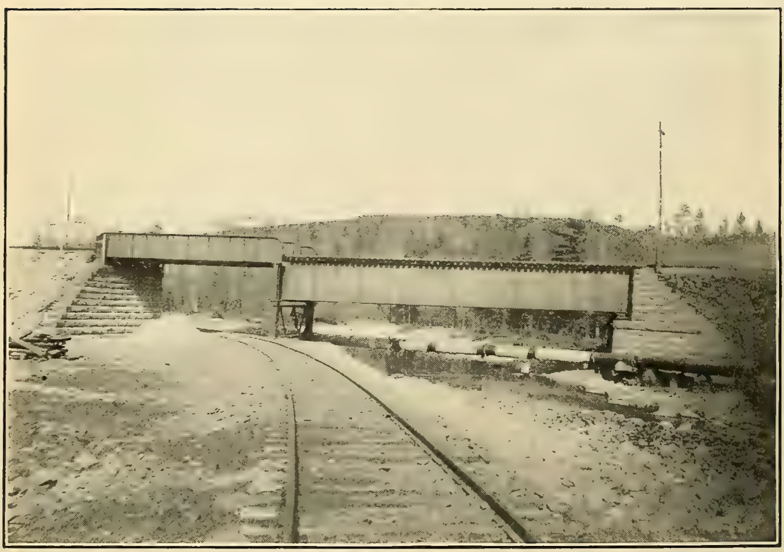
Concrete for the bodies of piers and abutments, for all wing walls for same and for the bench walls of arch culverts shall generally be made in the proportions (by measure) of one (1) part of cement to three (3) parts of sand and six (6) parts of crushed stone. In foundations and arches, proportions will vary according to instructions from the engineer.

All concrete must be mixed on substantial platforms of plank or boards securely fastened together, so that the various materials of the concrete can be kept entirely free from admixture of foreign matter; mixing on the ground will not be allowed under any circumstances. Satisfactory methods of measurement will be the use of headless and bottomless barrels or boxes boxes preferred) for measuring sand and broken stone. The measurement of sand and broken stone in the ordinary shallow, round-bottom wheelbarrow will not be considered satisfactory and shall not be permitted.

Molds of substantial character shall be made in which to construct all concrete work. The material for these shall be furnished by the contractor, and the expense of furnishing all such material and of constructing and of removing the same shall be covered in the price per cubic yard paid to the contractor for the several classes of concrete work called for. The face of all plank for molds shall be dressed on one side, and all plank used on the front surface shall be of a uniform thickness, and usually two and three-fourth (2¾) inches in thickness, for all important work, and the frame holding them in place shall be of sufficient strength so that they shall be practically unyielding during the progress of filling, tamping, etc. The frame work may be fastened together either by heavy wires or iron rods (in most cases wire will be preferred).

In case rods are used, a sleeve nut will be provided on the front end so the rod will not project through the face of the concrete when completed, and at least two inches short, so the hole can be filled with cement; the uprights or studding shall be placed not more than four (4) feet apart, and well cross-wired or rodded, so there will be no possible chance of their giving away. Foundation concrete may be put into excavations without the use of molds, provided the sides of the excavations are reasonably true and the material is sufficiently firm, so that the concrete may be rammed

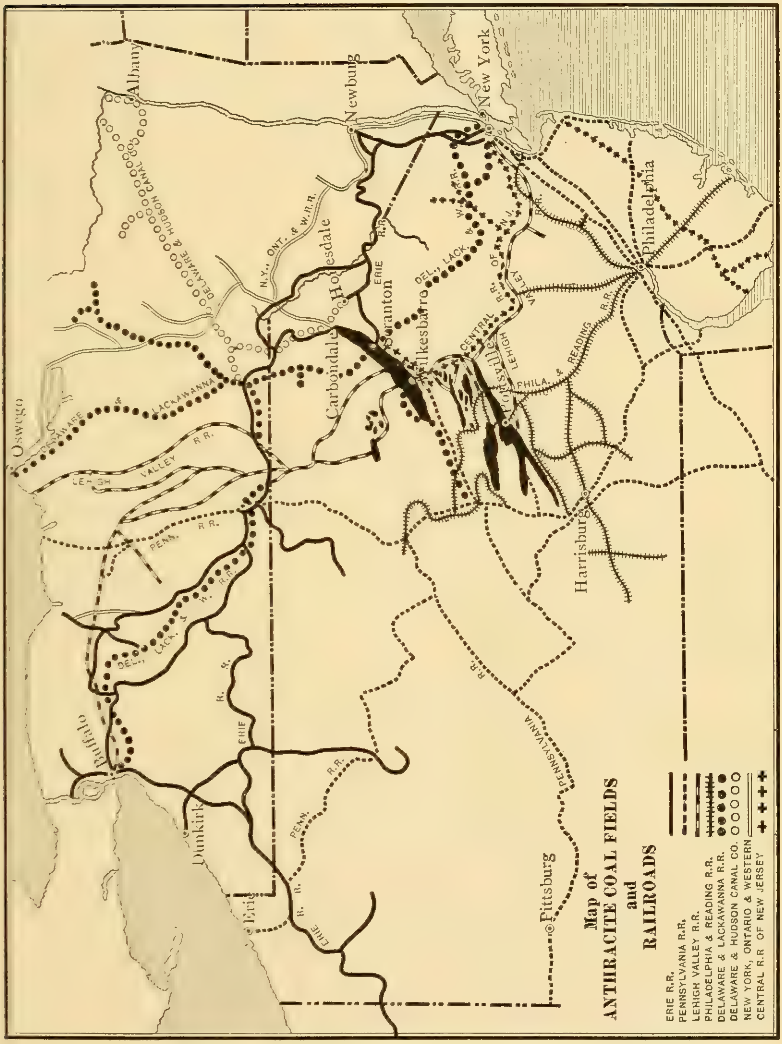
BROAD STREET BRIDGE, ERIE RAILROAD.



SPRING BROOK BRIDGE.

Cut, Broad to William Streets, Pittston.

Avoca Viaduct.



MAP OF ANTHRACITE COAL FIELDS AND RAILROADS.

thoroughly without yielding to the adjacent earth. The top of all foundations shall be finished smooth and level, the corners and edges being thoroughly rammed and compacted and the whole surface filled full of mortar. No honeycombed surface will be allowed. When anchor bolts are required, they shall be set in place and held firmly as to position and elevation by templates securely fastened to the mold and framing.

The bridges have been built under the specifications known as "Cooper's E 40."

On account of the exposure of the live third rail, the entire right of way has been fenced with wire fencing, and trespassing on the same is thereby nearly done away with.

The equipment consists essentially of the following kinds of cars, etc.:

One locomotive,

Ten single-end passenger cars (controller on one end only), divided in the middle for smoking compartment,

Three single-end combination cars, for passengers and baggage,

Four single-end express cars, for local package express,

Fifteen double-end multiple-unit cars,

Ten ordinary box freight cars and a repair car.

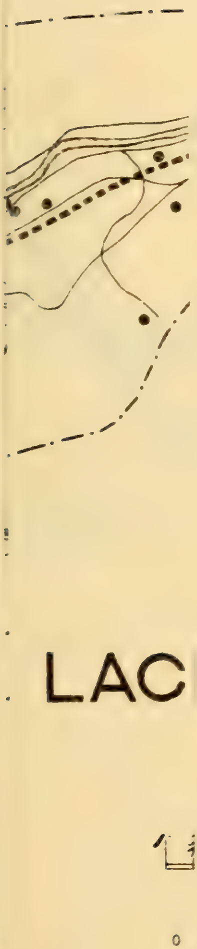
The passenger cars are electrically heated and lighted, are 52 feet long over all and have steam railroad trucks, equipped with two 150-horse-power motors.

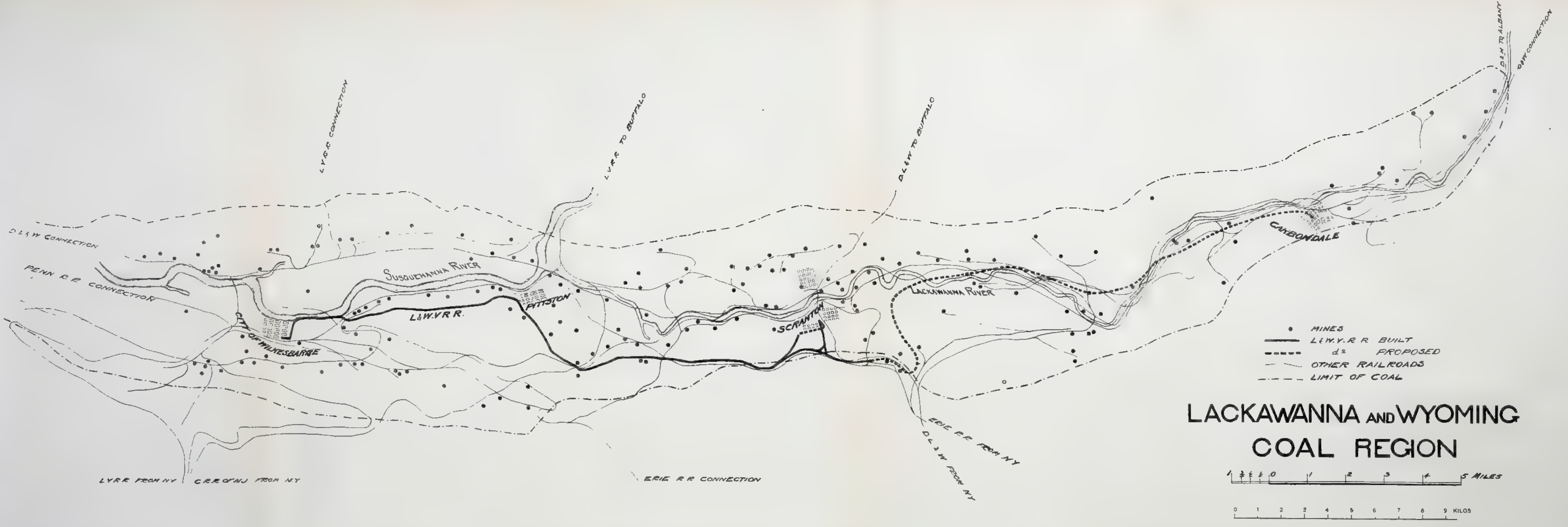
The car house, shops and power house are located on the terminal land at Scranton, alongside of Roaring Brook, a tributary of the Lackawanna River.

The car house is 177 feet long and 146 feet wide, and is 28 feet 6 inches high in the clear. It has two division fire walls, and each of the three divisions contains three tracks. One bay contains track pit and repair-shop conveniences. The building is fireproof throughout. The walls are of brick, the roof of steel trusses, with concrete and expanded metal for covering. The repair portion of the building is divided into blacksmith shop, machine shop, winding room, tool room, office, etc. It is lighted by electricity and heated by hot water.

The power house is 90 feet wide, 133 feet long and 42 feet high. The boiler room, which is separated from the engine room by a brick wall, is 42 feet wide and 26 feet 6 inches high. There is room for seven 400-horse-power Babcock & Wilcox water-tube boilers, of which five are installed. These boilers are equipped with Roney mechanical stokers.

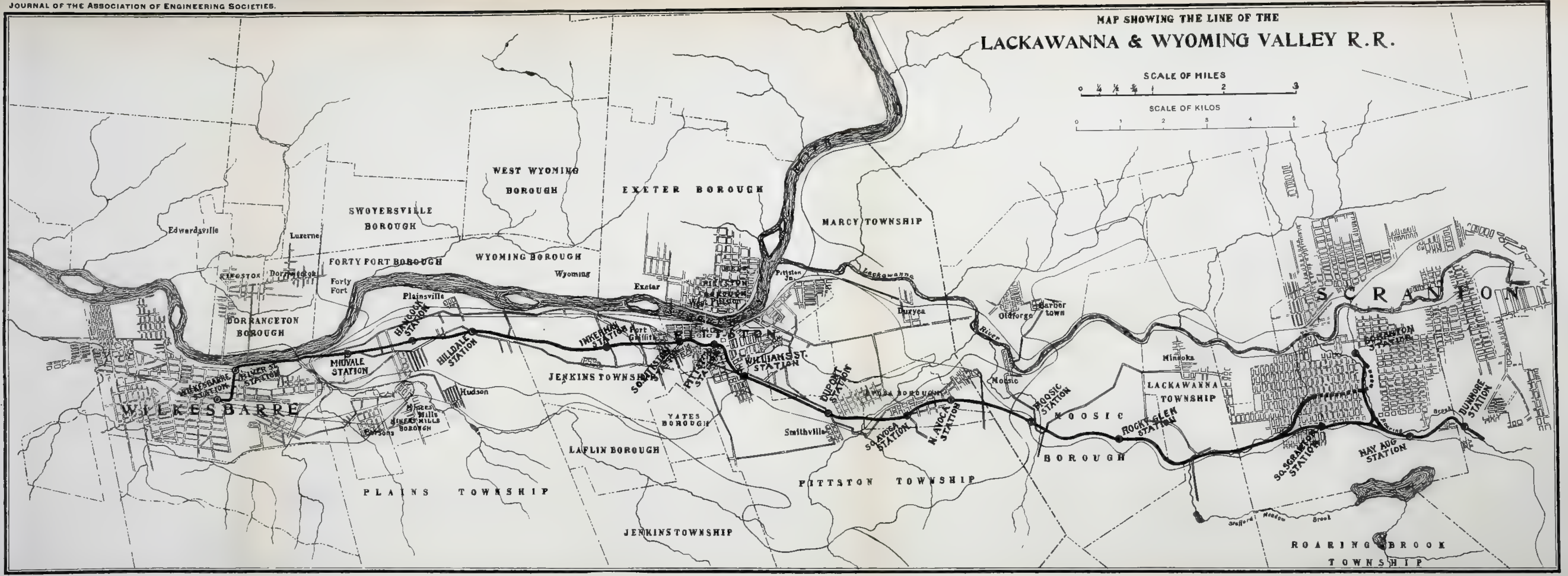
The coal and ashes are handled mechanically, by conveyor, through overhead bunkers and stokers, to fire, and then, as ashes, in an ash car running on a track beneath the boilers.


LAC

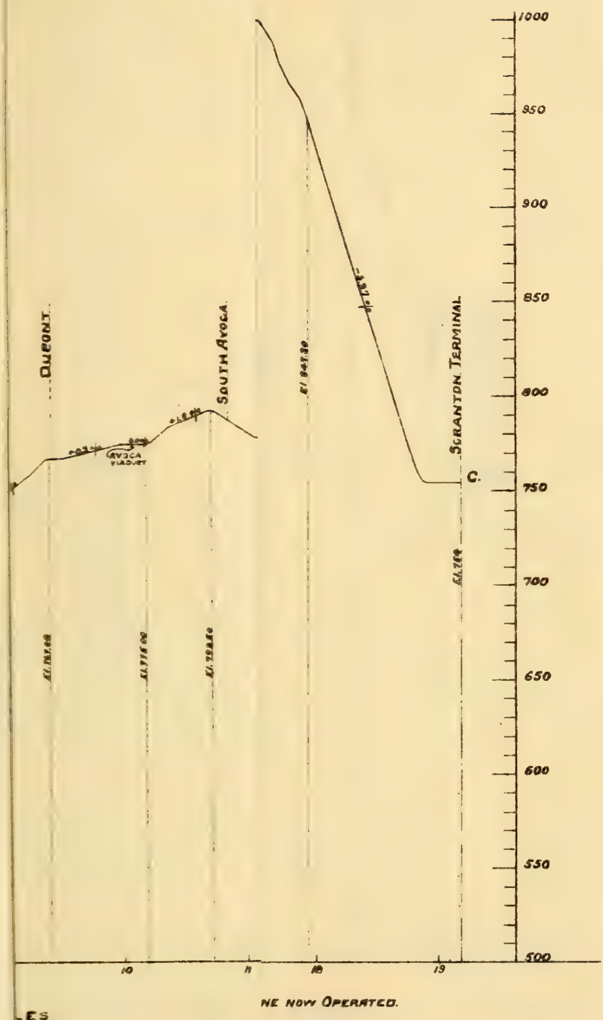


LACKAWANNA AND WYOMING
COAL REGION

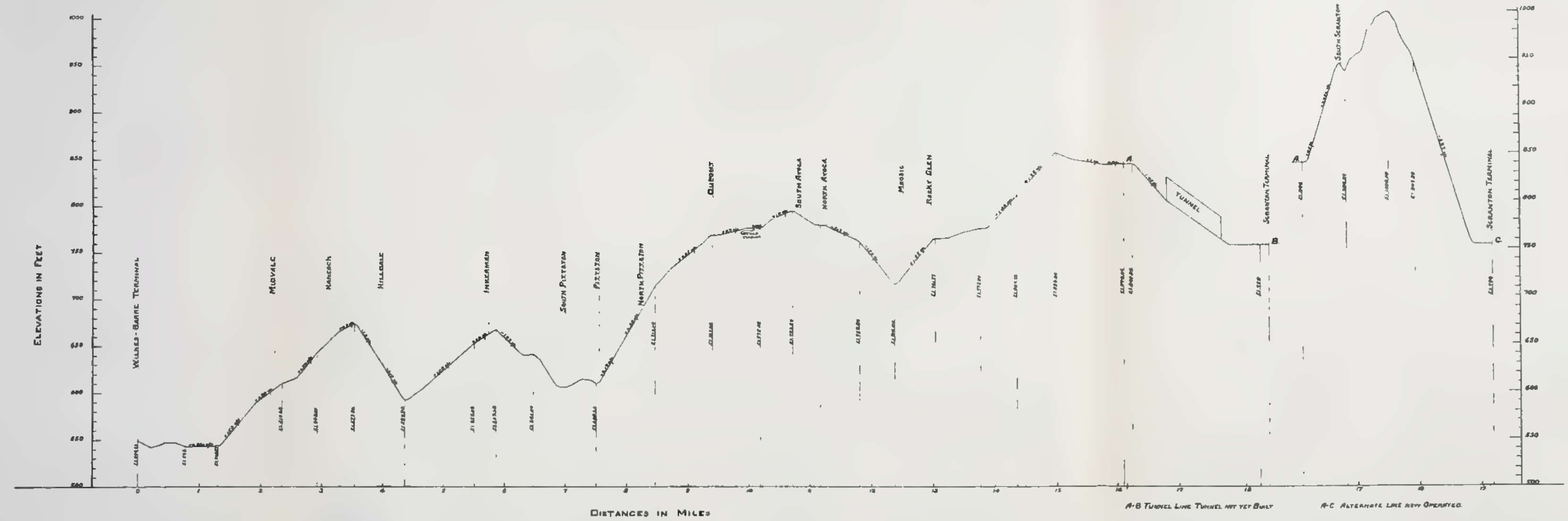

THE LI
YOMI
OF MILES
OF KILOS
8
oks
WANNA
NSHIP


MAP SHOWING THE LINE OF THE
LACKAWANNA & WYOMING VALLEY R.R.
SCALE OF MILES
0 ¼ ½ ¾ 1 2 3
SCALE OF KILOS
0 1 2 3 4 5
WEST WYOMING BOROUGH
EXETER BOROUGH
SWOYERSVILLE BOROUGH
MARCY TOWNSHIP
Edwardsville
Luzerne
FORTY FORT BOROUGH
WYOMING BOROUGH
Wyoming
Forty Fort
Exeter
Plainsville
DORRANCETON BOROUGH
HANCOCK STATION
HILLDALE STATION
INKERMAN STATION
MILLVALE STATION
RIVER ST. STATION
WILKESBARRE STATION
WILKESBARRE
Hudson
Parsons
JENKINS TOWNSHIP
YATES BOROUGH
LAFLIN BOROUGH
PLAINS TOWNSHIP
JENKINS TOWNSHIP
PITTSTON TOWNSHIP
WILLIAM ST. STATION
DUPONT STATION
Smithville
SO. AVOCA STATION
N. AVOCA STATION
Lackawanna
River
Duryea
Oldforge
Moosic
MOOSIC STATION
MOOSIC
BOROUGH
Minooka
LACKAWANNA TOWNSHIP
ROCKY GLEN STATION
SCRANTON
SCRANTON STATION
DUNMORE STATION
SO. SCRANTON STATION
NAY AUG STATION
Stafford Meadow Brook
ROARING BROOK TOWNSHIP

WYOMING VALLEY RAILROAD.



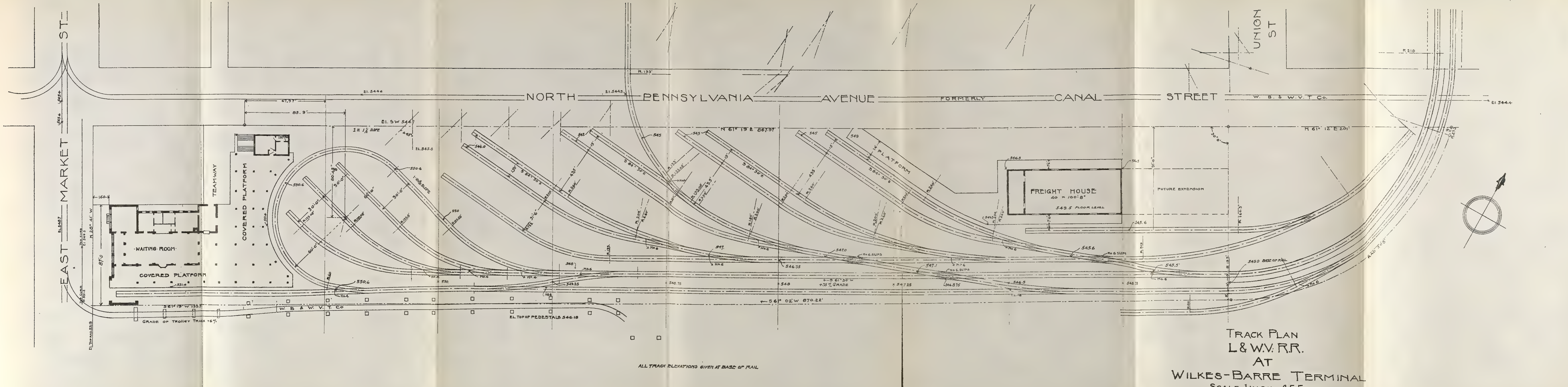
ARRE TO SCRANTON



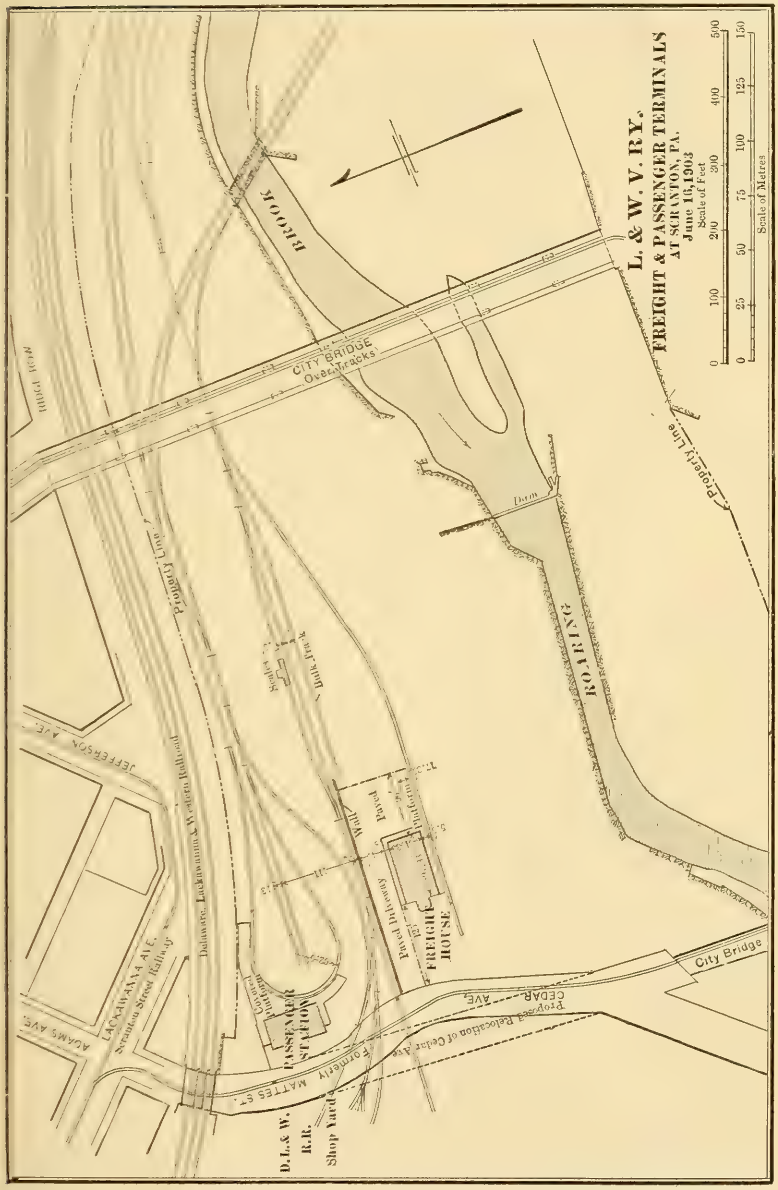
L. & W. V. R. R.—PROFILE OF GRADE FROM WILKES-BARRE TO SCRANTON

HORIZONTAL SCALE, 1 IN —5000 FT.
VERTICAL SCALE, 1 IN —100 FT

FEB 10, 1904.



TRACK PLAN
L. & W. V. R.R.
AT
WILKES-BARRE TERMINAL
SCALE 1 INCH = 45 FEET
OCT. 9, 1903.



FREIGHT AND PASSENGER TERMINALS AT SCRANTON.

The chimney is 118 feet high, 9 feet 10 inches inside diameter, and is of Alphonse Custodis construction. Worthington feed pumps are installed. The steam piping is standard, full-weight wrought-iron pipe, magnesia covered. The Holly gravity return system is used for returning drips to the boilers. The valves are extra heavy, with outside yoke and screw. The engine room is large enough to house three Westinghouse vertical cross-compound type engines, two of which are now placed. The rated capacity of these engines, with 160 pounds of steam pressure, is 2000 horse power, but they can be run at 60 per cent. overload. The generators are A. C. D. C. type, of 1250 k. w. capacity. There is also a duplicate set of exciters, independently driven. The other engine-room appliances, such as switchboards, transformers, condensers, etc., are all of first-class type.

At Hancock, fourteen miles from the main station, is a substation, equipped for reducing the voltage for conversion into direct current. This building is also arranged for a passenger station.

The pole line, from the main power house to the substation, consists of 30 to 35-foot cedar poles, set 5 feet into the ground and 100 feet apart. These poles carry three No. 4 B. & S. hard-drawn copper wires, arranged in a triangular form on umbrella-type glass insulators. The high-tension current is of 22,000 volts.

The third rail weighs 75 pounds per yard, and is unprotected. It is supported on each fifth tie (which is of extra length) and is bonded with two 400,000 C. M. bonds. At gaps there are two 300,000 C. M. cables placed under ground in conduits of creosoted wood filled with pitch.

The track is bonded with two 4/0 protected rail bonds under the angle bars. There are cross bonds of 250,000 C. M. every 500 feet along the track.

In Wilkesbarre there are several grade crossings of streets, and, for a short distance, an overhead trolley is used in place of the third rail, all of the cars being equipped with trolley poles. The contact shoes on the cars are of the gravity pattern and take the current from the top of the third rail.

The road is operated throughout the day on a twenty-minute interval between cars, with extra cars morning and evening, which make a ten-minute interval.

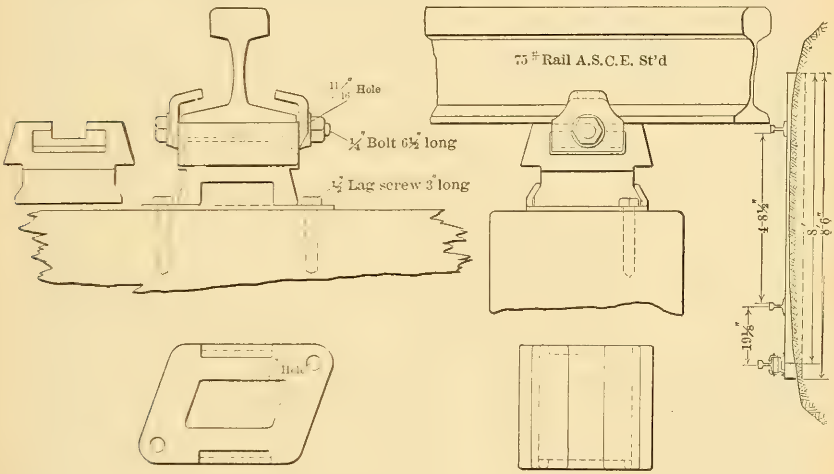
Special cars, on a five-minute or other interval, are run when required. Multiple-equipment trains will be run as required.

The public appreciates the convenience of the road and gives it a liberal patronage. As far as possible, tickets are used, and the

general rate is one and one-half cents per mile. Cash fares are a little higher.

Westinghouse, Church, Kerr & Company, of New York, have acted as Chief Engineers, Auditors and Contractors for the electrical equipment, stations, track work and rolling equipment.

The Security Investment Company, of Pittsburg, Pa., has managed the financial part of the operation. The other principal contractors have been John R. Lee, of Paterson, N. J., for grading, masonry and ballast work; The King Bridge Company, McClintic-Marshall Construction Company and Phœnix Bridge Company, for



THIRD-RAIL INSULATOR, LACKAWANNA AND WYOMING VALLEY RAILROAD.
Distance from Top of Running Rail to Top of Third Rail, 3 in.

bridges, and The American Car and Foundry Company, for equipment.

The total cost of the road, as far as constructed, including right of way, terminals, grading, masonry, track, power house, electrical work shops, car house, etc., has been nearly $6,000,000.

Mr. Charles F. Conn has acted as business manager during the construction, and is the Vice-President in charge of operation.

Mr. George F. Huggans has been the Civil Engineer in immediate charge of location, grading, masonry, bridging and track work.

Supervision of the building work and electrical equipment has come from the office of Westinghouse, Church, Kerr & Company, and has been largely executed on the ground by Edward M. Decker.

THE VALUE OF INSPECTION OF METAL BRIDGES DURING CONSTRUCTION AND ERECTION.

By Walter L. Golden, Member of the Engineers' Society of Western New York.

[Read before the Society, May 5, 1903.*]

When a superabundance, or at least a considerable amount, of literature has appeared on any subject in which engineers or those interested in engineering enterprises are concerned, further suggestions are usually offered with some deference or apology; and, while some discussion and not a little criticism has appeared now and then on the question of the value of inspection in our technical publications, an impartial presentation of the facts and conditions of the inspection business will perhaps not be an unwelcome subject to those present, and not without interest to those unacquainted with the practical workings of an inspection bureau.

In our great system of civil government we recognize three departments—legislative, executive and judicial. We intrust the legislative with the work of framing the statutes, rely on the executive to enforce them and on the judicial to solve all questions arising as to their validity. Now, while our faithful legislators may give us an ideal code of laws, the essence of a model government, we still consider enforcement by the executive as absolutely essential, and consequently the judicial; even though the latter may often be found wanting and may be subjected to just or unjust criticism, we would consider it the height of folly to dispense with their services on this account.

Similarly, an intelligent engineer, when he has drawn up his code of rules, or specifications, as we may call them, in accordance with which a bridge or other structure is to be built, may expect to follow the work with his watchful eye, or that of those in his employ, to see that his designs and methods be not accidentally or intentionally disregarded. His envoy of protection is the inspector, who, though often the object of abuse and criticism, deserved or undeserved, cannot be dispensed with any more than can our executives of the law, who may at times come short of their duties. The only hope lies in their betterment by organization and co-operation of the individuals they protect.

One of the exponents of the engineering profession prefixes his specifications with this pertinent clause: "The most perfect

* Manuscript received March 12, 1904.—Secretary, Ass'n of Eng. Socs.

system of rules to insure success must be interpreted upon the broad grounds of professional intelligence and common sense," evidently realizing that there must be considerable latitude between the text and practice of building bridges and other structures; the one is the ideal, the other the practical. But, even with this expectation of a certain difference or leeway between the two, the contractor undertaking the work would hardly be given the liberty of taking an "inch or mile" as he might see fit. Here the inspector has an important duty to perform, for, though the standard of shop work is constantly improving, and in its present methods of system and precision which characterize the modern bridge shop is one of the marvels of modern manufacture, this can hardly be said for the honest performance of that work, and this inspection must regulate.

The inspection of iron and steel structures dates back to the time when the first were constructed, though the service has until a dozen years ago been performed by the engineer, his assistant in charge or some individual employed by him for this service. All the railroads had their own corps of inspectors under the engineering department, and the old iron bridges of earlier days were subject to the most rigid kind of inspection in manufacture, erection and maintenance. Later, certain men of some engineering and practical experience took up this line of work exclusively, and performed the service for the engineer at a fixed rate. As demands for the service of inspection increased, due to the more universal use of steel for structural purposes and the consequent boom in building structures of this class, the services of these inspectors being required in a number of mills and shops located in widely separated districts at the same time, the formation of so-called inspection bureaus became a necessity, in order to economically perform the work. So that one man, instead of traveling about to various districts on work of a varied nature and following each job through consecutive stages of mill, shop and field, and thus wasting much time and money in traveling, located in one district under the employ of the bureau, cared for all their work (secured from various engineers) in that district, be it at shops or mills, and other representatives cared for that portion of the work in other districts. The present custom of ordering material for one job from a number of mills wherever the best price and time limits for delivery can be secured, and likewise subdivision of shop work to different companies or different plants of one company, has made the system of co-operation of inspectors and consequent formation of bureaus a necessity. To-day the most extensive railroads still have their own inspection corps; some, however, prefer to have

this work performed by outside inspectors, in the aggregate amounting to thousands of tons a month—only one factor which makes the inspection business so extensive and keeps a considerable number of these bureaus alive. Added to railroad work is that of highway bridge construction, structural buildings of all classes and machine construction, including all mill and shop equipment and conveying machinery. To illustrate the variety of inspection, here is a catalogue showing the various lines of inspection under the care of one bureau on which they are working at the present time: Bridges (railroad and highway), buildings, ship hulls, boilers, machinery, locomotives, steel and wooden cars, standpipes, riveted water pipes, steel rails and cement; it also maintains a laboratory for chemical and physical tests of building materials. An idea of its extensive practice may be had when it is known that this bureau inspected and tested materials for seventy-five different railroads in the three years, 1898 to 1901, and this only one of half a dozen or more such bureaus; nothing can better show the recognition inspection has commanded in the last few years.

The first regularly organized inspection bureau was that of Hunt & Clapp, Pittsburg Testing Laboratory, in April, 1883, the next following soon afterward, that of G. W. G. Ferris & Company, and, later, R. W. Hunt & Company, Osborn Engineering Company, J. A. Colby and R. W. Hildreth & Company. Of the large bureaus such as these, there are not more than eight concerns, and, added to these, a number of smaller inspecting firms. In the Philadelphia district (the most extensive for rolling and fabrication of structural material), five of the large bureaus are represented and half a dozen of the smaller ones.

An inspecting company, to perform its work effectively and economically, requires a carefully organized corps of inspectors and clerks. A regular detailed system, approved by experience to be capable of operating with regularity and uniformity, is the only safeguard against mistakes, lost records and careless work. It may be of interest to follow through the various stages of inspection in the usual order as practiced by inspectors, and note what care is taken to secure for the engineer and purchaser the structures they have ordered and expect to fulfill certain conditions and specifications. The natural order of work is mill, shop and field inspection, and, while each of these three may be complete before the next is begun, it is more often the case that all three classes on one structure may be going on at the same time, nearly up to the state of completion. The third stage, that of field inspection, in many cases is not performed by the bureau having mill and shop

work, but is either looked after by a regular field inspector hired by the engineer, by the engineer or his assistant or by no one at all, the last being not an unusual occurrence in some classes of work.

First Class: Mill Inspection.—When a contract for a bridge or other structure is let, the engineer notifies the inspecting company and bridge company who are to do the work, the former being supplied with a copy of the engineer's plans and specifications. The plans are examined and forwarded with special notices and memoranda to the inspector located at the contractor's shops. The bridge company orders the material at one or various mills and sends duplicate copies of these orders to the inspection office, which in turn sends one copy of the orders to their inspector at the mills; the estimated weights of the order are then made and kept for reference. Each mill inspector compares the order he has received with the mill's own order, to see that no change or mistakes have been made. As the steel is rolled, test specimens are cut from different sections on each heat, as specified, and the physical test for ultimate strength, elastic limit, elongation, reduction of area, character of fracture, cold and quench-bending tests are made, and such additional tests as the engineer or specifications may require. Record is kept of these tests, and if in conformity to specifications are accepted; if not, rejected, and new tests ordered and made; in case these fail, new material is required. Drillings are also taken from each heat for chemical analysis, and this is performed by the mill chemist and his work turned over to the inspector, who forwards all these records to his home office (retaining his own copy), and the office forwards copies of them to the engineer. As fast as rolled, the inspector is required to examine material for surface defects and flaws, straightening, size, proper handling, etc., noting that the shapes bear the heat numbers for which he has pulled his test. He informs his home office of the material he inspects each day, and as material is shipped he checks the invoices for the same with his mill-order copy and estimated weights.

At the head office the items on the invoices are again checked when received and forwarded to the engineer. Thus the engineer is kept reliably informed as to the condition of material for his work, both as to reliability shown by testing and promptness of manufacture and delivery; he cannot be deceived by excuses or needless delays on the part of the manufacturer. In following out the above order of his work, the inspector, of course, may meet various disagreeable complications; for example, it may be that

when the order for material was placed at the mill no mention was made of inspection or the specifications covering it; this information is often suppressed intentionally to get a cheaper price on material; in this case, the appearance of an inspector at the mill is hardly a pleasure to the mill manufacturer. Much has been written and said of late as to the real value of mill inspection of structural material; some question whether it is really necessary that it should be done at all, but simply accept the manufacturer's guarantee that the material is all right. Boiler plate, armor plate, guns, eye bars, cable and other similar material are inspected and tested with great rigidity and care, are required to come closely within specified limits and are rejected as unsafe if they fail; but can inspection of the enormous amount of structural steel manufactured into our buildings and bridges be ignored or left to the manufacturer? The object of the inspection is to give to the engineer an independent assurance that the material, tested according to specification, is a good, suitable quality for the purpose intended; he also wants the least expensive way of arriving at this assurance. Now, the manufacturer can see no reason why material pulled at fifty thousand pounds per square inch should be rejected as being low in tensile strength when the designer has only used fifteen thousand pounds as a tensile strength for the basis of his calculations; to his mind, it is good enough. The natural result is that this rejected material, though not suitable for one order because of rigid inspection, will be acceptable on another where there is poor inspection or none at all. The engineer specifies that his structure shall be made of material of uniform hardness and strength, not hard in one part and soft in another, or weak in one piece and abnormally strong in another. Not that these conditions, if they do exist, will cause the structure to fall down; but to have it correctly proportioned, and take no chances on any part of it failing, he guards against them.

He may rest assured the contractor, with his own business interest at heart, will hardly co-operate with his views, unless an independent umpire is at hand to protect *his* interest. So much for *testing* material.

As to surface inspection, it is the opinion of many that surface inspection does not pay, as the mills guarantee all their products and agree to replace, immediately and without question, any material thrown out at the shop because of surface defects. To the writer it appears that certain surface inspection *is* necessary and should be insisted upon; material should be inspected for heat numbers, to see that they correspond to those for which the tests

were pulled. As to defects due to imperfect rolling or crop ends resulting from not cutting off a sufficient amount at ends of the pieces, it is far better, if possible, to inspect these at the mill. Suppose the mill *does* agree to replace anything rejected at the shop; they are aware full well that in doing this a certain amount which passes at the shop would not pass at the mill. The reason for this is that in the course of the manufacture of a bridge, in the usual hurry to get the contract out on time, faulty material will in many cases be used as not being seriously defective, or else be supplied from stock carried by the shop. The writer has in mind a defective I beam, a part of a large building under construction at an Eastern shop; there had been a lap in rolling, and any mill inspector would have rejected it as defective. The shop superintendent placed it on supports at either end and, giving it a few blows with a heavy sledge near the middle, where the lap occurred, without any apparent effect, pronounced it satisfactory, and it was used in the structure; this building was a case where inspection was not considered necessary. As to the practicability of surface inspection, it can be secured at the smaller mills; at the larger ones it is a very hard matter. To secure it at these mills it is necessary for purchasers and engineers to demand that the mill shall provide a suitable place for the material where it can be inspected between the process of rolling and loading, if surface inspection is to be thoroughly accomplished.

Much has appeared in the last few years relative to further tests and examinations of steel and iron other than a tensile and bending test, upon which material is accepted at present. Without describing in detail the new methods, mention of only the important ones may be of interest. Messrs. Hunt, Allen & Condron have made tests of material, using a new machine constructed by them, which measures the amount of work done as this machine punches or shears a plate or other test-piece, showing more nearly the strength developed by the material in the actual shop working of it than a simple tensile test. The impact test is also one of recent development, detecting inherent brittleness of materials, and has a large field of usefulness. The method and machine for testing materials for impact was invented by Mr. S. B. Russell, member of the American Society of Civil Engineers, and he presented a paper on the subject before the American Society in 1899. A very important quality recognized by engineers is that of resilience, or resistance of steel to sudden shock. The work done on the test specimen and its resulting change of form is a valuable addition to the physical and testing laboratory. Its practicability for regular

tests on manufactured material is still to be recognized. Mr. F. S. Rice has made some worthy suggestions on the value of microscopic inspection of steel, resulting from examinations he has made of specimens (some of new material and others of old material long in service), and they go to show that from specimens which are carefully polished, when examined with a microscope of no very high magnifying power, much can be learned of their composition and texture. All these methods of testing are worthy of consideration and would make valuable supplementary tests to those now in common use; it may not be long before some of them will be adopted, and recognized as not too expensive to be specified for regular tests of structural material.

Second Class: Shop Inspection.—In the manipulation of material and the many details that are involved in its manufacture into one complete structure, a shop inspector is, of course, a prime necessity. His duties are a category which, when carried out in all its details, keeps him a busy man from the start of the contract to its finish. If true in the mill, it is doubly true in the shop that unless all workmanship during the stage of manufacture in the shop be competently and honestly inspected, much of the purpose of scientific design and specifications is destroyed. To those unacquainted with shop practice or how it is carried on in a multitude of plants, both great and small, the many ways in which work can be intentionally or not intentionally slighted, and the subterfuges used to hide these variations from specified rules, would be somewhat of a surprise; in this day of large output, when each shop is straining every nerve to manufacture material up to or beyond its rated capacity, the superintendent and his foremen, in their eagerness to satisfy their employers, can hardly be expected to watch the engineer's interests; the quickest and cheapest way, with reasonable certainty of holding together, is their business motto. In fact, the shop drawings are about all the men work by, with the notes added thereon from the specifications of certain features which, in the judgment of the shop's engineer or draftsman, are worthy of mention; in half the cases where the superintendent's attention is called to points in the specifications not being followed in the work he is ignorant that such a specification exists. It may be his duty to read them, but is often his privilege, and perhaps duty, to forget. So for these reasons it is not hard for a casual observer, when passing through a shop, to note which contracts are under inspection and which are not. The practice of subletting parts of contracts in certain shops and classes of work requires careful inspection both to keep track of the structure as a

whole and watch its manufacture. Though this practice is often economy or perhaps a necessity to a shop not able to perform the entire contract, competition may cut the price to a figure, at which good work can hardly be done. This is sometimes explained afterward by the subcontractor in the statement that inspection was not figured on when the work was taken.

Some very interesting and practical tests for built-up girders and truss sections were recently made by special arrangement of certain interested engineers with one of the large structural shops; the results showed in the girders tested that 21 per cent. was added to their strength by drilling rivet holes and use of power riveting. Other sections showed even greater superiority of high-standard work over the ordinary. Care was taken in drilling and riveting these sections, of course; but only the same care which would also be taken on work under good inspection. Now, on those structures where the engineer specifies solid drilling, or even reaming of punched holes, it behooves him to have this work watched very carefully, if he considers this added strength necessary to his structure.

Punching full size, up to certain thicknesses of material, is, of course, much cheaper than drilling or reaming, and will be done if possible. The machine riveting will in most cases be done, but there is a good and also a bad way of machine riveting. These tests are only one thing which goes to show in what degree good or poor manufacture may influence the efficiency of the structure.

An investigation into the collapse of a bridge over Tinker's Creek, Bedford, Ohio, back in 1896, was a case of no inspection; added to the fact that the bridge was weak in design, the material was passed with a high percentage of phosphorus, and double punching of holes in tension members was allowed. As a result, the bridge collapsed under a heavy live load.

The routine work for a shop inspector is something like this: As soon as the material begins to arrive at the shop he makes weekly reports on the work to the general office; he receives from the bridge company a full set of drawings for the structure; checks them with the engineer's plans in detail, and also by themselves in detail; he makes a careful estimate of the weights of all parts and a complete marked list of the same; in checking drawings it is often necessary for him to alter field connections to facilitate erection and many other minor details; it is his duty to be about the shop at all times and during progress of his work, and watch the various processes of manufacture from start to finish, that they be in accordance with his specifications; he inspects the condition of ma-

terial before fabrication and identifies it as that rolled for his structure; by watching all stages of manufacture closely he can stop poor work that may be covered up or hidden in the finished material, and can correct errors easily, saving time and expense for the shop, to say nothing of expense and profanity in the field. When finished, he gives the pieces final examination and checks their measurement in detail; special care does he use in checking clearances and field connections, two most important points and at the same time the most difficult to check from a shop inspector's standpoint; the painting inspected and work accepted, he stamps the material *as* such, and, after seeing it weighed correctly and loaded properly, he reports its shipment in detail; he receives copies of the shop invoices for the shipment and checks them carefully, informing the shop and his office of errors in the same. He reports each week on three forms: first, of mill material on hand for fabrication; second, of work in process of manufacture; third, shipments of finished work. At the completion of the contract a detailed final report is prepared, showing actual and scale weights of all material in classified form, and also a complete report of all shipments made and data concerning them, accompanied by a descriptive report of the process of manufacture, noting any unusual features or defects that may have arisen, rejected material, causes for delays in progress of the work and other data for record. All these reports and records are made in shape for filing, the inspection bureau keeping duplicates of them as furnished to the engineer; at any future time, any question arising concerning the structure, reference can be made to them and the information furnished by the bureau, if desired. The inspector is also required to keep a diary record of his work and time spent on each class of work, with expenses chargeable to each, and send each week to his office, where a check can be kept on his movements and disposition of his time. This is the routine work of a first-class bureau's inspector, and this category requires him to be a very busy man; the wide range of his work demands it, and the most important point in good inspection, in fact the thing which distinguishes it from bad inspection, is that of his presence at all times during manufacture; a cursory examination of *finished* work may be *inspection,* but it is not *good* inspection; it is, rather, *assumption,* and much of the value of inspection is lost; we may add that it is lost when cheaper inspection is secured.

All of the larger shops now employ, and have employed for a number of years, a shop inspector of their own; his work includes all jobs passing through the shop, and with a copy of the drawings

in hand he goes over, as far as possible, field connections, as a check on the accuracy of the various workmen, and for this part of the work he is responsible to the shop; *there*, however, his duty ends; unless there is something extremely irregular about the material as finished which may cause trouble in erection, he distinctly understands that in serving the interests of his employer anything further is out of his jurisdiction; and the manufacturer expects that any further correction will be called to his attention by the outside inspector, and not his own.

As to the attitude of the shop toward the first-class inspector, as a rule it depends on the amount of trouble the inspector finds it necessary to make for the shop; errors in manufacture, anything that will prevent the material from fitting properly, the former will gladly listen to and correct; but further than this, as to faulty manipulation, careless finishing and the like, the inspector finds that the manufacturer is not easy of persuasion, and sometimes is both stubborn and aggressive under the force he may be obliged to bring to bear on him. The superintendent regards his own methods as good enough, for he considers cost and output at the same time; and, in the event of any interference, he either tolerates the inspector as a necessary evil or seeks his removal; and, in justice to the inspector and the standing he has obtained in the shops in latter years, it is much harder for the manufacturer to have him removed on any complaint of his own than it was a few years ago. In the majority of such cases the inspector against whom the greatest cry is made is the one who is most thoroughly trying to fulfill his duty.

A few engineers have attempted at times to specify that the manufacturer shall make certain specimens of full-size sections similar to those entering into structures of importance, for the purpose of testing by loads and stresses similar in character for which they are designed; this work has been done in a few instances, but, of course, the manufacturer does not accede very heartily, and it will require the concentrated action of both engineers and inspectors to make these tests in future as customary as they are desirable. It would certainly give all concerned a much better idea of just how much our sections, details and connections are exceeding or falling short of what they are supposed to carry, and at the same time show the standard of *shop work*. These added tests, of course, would only be considered necessary on important classes of structures.

Third Class: Field Inspection.—To any fair-minded engineer, field inspection as a supplement to mill and shop inspection on a

structure is a prime necessity, and it is recognized as such on about all railroad work and usually on all important structures. In many cases the structural engineer has his own field inspector or a corps of field inspectors, though of late years a considerable amount of it has been done by inspection bureaus.

The railroads, unless they are small roads, have their own field inspectors on construction as well as maintenance. The Government usually does its own, also, though in some few cases outside inspection is employed. Any engineer acquainted with the usual methods and workmanship of erection must know that mishandling of the material or faulty work at this stage of the structure may undo many points of design that may have been successfully secured in shop manufacture, and render it not only weaker than it was designed, but weak enough to cause actual failure sooner or later. And yet it is surprisingly the case that on a large class of building work and not a little bridge work good field inspection is considered too expensive a luxury to warrant its employment.

Some architects, engineers and purchasers expect to pay a reasonable price for the inspection of large and necessarily expensive structures, but little or nothing for that of smaller and less expensive structures. Of structures failing and causing loss of life and property, the majority are not of the ultra-expensive class; and, without saying that lack of inspection was the direct cause of failure, in many cases, where no attention is paid to the workmanship on erection of this class of structures, failure can be reasonably expected. Many of the insurance companies are looking carefully into the conditions under which a structure has been inspected during manufacture and erection before issuing a policy on the property.

As to the duties of the field inspector, though not so numerous or varied in character as that of his comrade in the shop, in performing his daily routine of work he usually finds plenty to keep him busy if the work is proceeding with reasonable rapidity. He keeps a record of all material delivered at the bridge site and sees that it is unloaded and transported properly from the cars to its place in the structure, examining it, at the same time, for injury received in transportation and errors in shipping invoices of each carload; it is necessary for him to be thoroughly acquainted with both the original design and shop details of the bridge, if the structure is of any complicated nature whatever; in fact, he must understand it so well in all its connections and details as to know where

each separate piece is designed to fit; these details the foreman, and even the superintendent of erection, in nine cases out of ten, knows little about, and as a usual thing both rely on the inspector for this information. To the uninitiated it is surprising, in structural work, how a little misplaced material, which at first sight may seem to fit in place, is found, a little later, to belong elsewhere, the consequent change perhaps entailing much trouble and expense; the *shop marks* on all of these pieces usually govern the erector, and he unfortunately pins his faith on a not very certain guide; especially is this true in work that has been wholly or practically all assembled and the field connections reamed in the shop; to obtain the best results and benefit derived from this method of insuring good field holes, the parts must necessarily be assembled the same way in the field; and, without inspection, this will in most cases not be done. The inspector examines the quality of all workmanship on the bridge, and any attempt to slight or injure the work he prevents before it proceeds further; he is the engineer's daily representative on the job, and reports to him all matters and questions that arise in its prosecution; also, all difficulties and delays of an irregular nature, and these he incorporates in a report to the engineer weekly or oftener, as circumstances may require. It is evident, to carefully and thoroughly carry out this regimen of inspection, faithful and constant watchfulness is the engineer's only hope for a perfect job. No mere cursory examination at irregular or even regular intervals, such as is the all too common practice on some classes of work, will secure it for him; not only does it apply to steel work, but also all other materials entering into important parts of the structure, especially those subject to loads.

The collapse of a building under construction in New York in September of 1896 is only one example of the fact that building operations in every city need to be very carefully watched, in the interest of public safety, to prevent careless and willfully bad work being done. This was by no means the first accident of this character for New York City. The city building department was blamed, but a lack of appropriation for building inspection was the real cause of the disaster. There was, in 1896, in New York City, $90,000,000 expended for new structures, and in the same year $177,000, or one-fifth of 1 per cent., for inspection. From $\frac{1}{2}$ to 1 per cent. should have been allowed for this class of work. Granting every city building department to be honestly and efficiently managed, and every one of its inspectors to be absolutely honest and faithful, it is still certain that, with the limited appropriations which are generally allotted to city building departments, their

inspection must be too hasty and incomplete to insure discovery of every defective building, even though they may usually succeed in doing so. The time may come when this will be remedied—when ampler means will be furnished to building departments for their work—but it should be fully understood that under existing circumstances the inspection made by the city should never take the place of or relax the vigilance of the inspection that should be carried on on behalf of the engineer or architect and the owner. In *this* class of inspection a great opportunity for improvement exists. The best architects, conducting a large and well-systematized business, have an efficient corps of inspectors; but on the great bulk of building inspection carried out under the direction of ordinary architects, or in many cases without the aid of any architect, inspection is often a very crude attempt. That this should not be goes without saying. The owner of a building is responsible for its safety and can be held for damages if it fails, due to faulty construction; his insurance policy is also void in case of failure of the building; therefore, if he neglects to provide inspection to secure its safe construction he runs a heavy risk. Besides, an expenditure for inspection will mean, in many cases, a more durable structure—one that will involve less expense for repairs for many years; his attempt at saving by disregard of inspection is in reality a waste. There is an opportunity for the establishment of inspection bureaus for this class of work (that of building inspection) similar to those for structural bridge work. At present, the purchaser of a building has no adequate assurance that the structure is securely built. Such purchaser would pay somewhat more for a structure, if with the deed he received a certificate of an inspection bureau of wide reputation that the structure had been continuously inspected during its construction and received its approval. And when purchasers asked for or demanded such certificates, the builders who erect to sell, or owners building for investment, would find it to their advantage to employ such a bureau. Moreover, such a bureau can perform the work of inspection more efficiently and economically than the ordinary architect. He could have special men for machinery, lighting apparatus and other details of the work with which the average architect or his assistant are often not familiar. Thus, many architects would prefer to place the inspection in the hands of a bureau rather than undertake it themselves. This solution of the building problem is dependent, in a great measure, on the *purchaser's own demand* for safe inspection.

Following the field inspection of work under construction on

bridges and other important structures is that of *maintenance inspection* and provisions for its prosecution.

Special means for obtaining easy access to the superstructure of large bridges in order to perform the necessary work of inspecting, repairs and painting, is a matter which deserves greater recognition than it has generally received from engineers. European bridge builders have paid some attention to such features in a few instances, an example of which is the great steel-arch bridge at Muengsten, Germany, where an elaborate system of traveling staging for reaching all parts of the metal work were designed and built by the engineers as a part of the bridge; but in America there is not one similar structure where such devices have formed a part of the original work. This fact is all the more noticeable because of the number of really large bridges in this country where suitably designed inspection staging or platforms could have been constructed at a very small cost compared with the saving effected by them in future inspection and repairs. No engineer needs to be told that it does not matter how well a bridge may have been designed and constructed in the beginning, it has to be inspected and repairs made frequently thereafter; also, periodically painted, under inspection, as long as it is in service. In nine cases out of ten, moreover, it depends upon the *ease* with which access can be obtained to the metal work which needs these attentions whether care is given it at once, when it will result in the greatest benefit, or whether it is deferred until the conditions are such that the work *cannot* be deferred any longer. One of the most creditable features of the Muengsten bridge cited as an example above (a double-track bridge over 1500 feet long) is that every member of the whole superstructure, including its great arch span of 550 feet in the center, can be easily reached by engineers or inspectors who may for any reason desire to examine it.

The price of field inspection, though often based on the tonnage of the work, as mill and shop inspection is done, is in many cases let to an outside inspection bureau on a day basis. This, in many cases where progress of work is slow, is the only profitable way by which it can be done.

The writer had hoped to be able to describe at some length the condition of inspection work and recognition that inspection receives in the countries across the water as compared with our own, but, unfortunately, was unable to secure any complete data in the limited time available. England, however, has regular inspection bureaus, similar in operation to our own, and structural iron and steel are carefully inspected in rolling and manufacture.

In Germany, the entire work, including inspection, is vested in and performed by the engineer in charge and his assistants, and the system of inspection bureaus is almost entirely absent.

In conclusion, it may be of interest to note a few of the reasons usually advanced by engineers or purchasers why inspection is not necessary:

First. Reliance placed on the honesty of a good bridge company. To be sure of satisfactory results, with no check on the quality of the work turned out, and to look upon such a check as reflecting on the honesty of the bridge company, is a view that is hardly consistent in matters less important. We look upon a man who buys a watch as a *fool* if he pays for an Elgin and gets a Waterbury because he did not examine it before purchasing; yet when a purchaser accepts and pays for a bridge he accepts blindly his new possession with only the verbal guarantee of the bridge company. It is not a question of the integrity of the company or its management; but through all the hands that the tons of material must pass on its way to completion, each individual leaves the results of his work, either good or bad, and each man will look to his own interest first; everyone in the concern's employ, from the laborers to the manager, recognizes that "business is business." The purchaser would cease to be scrupulous on this point if he kept this trite saying in mind when tempted to trust to the tender mercies of the manufacturer; on the other hand, the bridge company that has nothing to fear from the inspector will welcome him to the shop to see that the work is done in the best possible manner and up to the standard of the structures for manufacture.

Second. That the work in hand is hardly of enough importance to warrant inspection. In this day of economic construction, when the parts of a structure are designed so accurately for their intended loads, the allowable working stresses and resulting sections are figured proportionately the same on one class of work, whether it be for light or heavy load; even granting that lower factors of safety be used on secondary work, they are used not because it is considered that less care will be necessary in manufacture of material, but because in supporting the lighter loads the uncertainty of sudden heavy loads and impact which may be developed in a structure of greater magnitude are in a great degree lessened; and, as was pointed out before, it is in this great middle class of structures that failures mostly occur.

Third. That the work will be seriously delayed by inspection, owing to the time required for the duties of the inspector. As a matter of fact, material that is being manipulated rightly, with

good workmanship in every way, is not delayed in the least by the checking and examination the inspector gives it. Complaints of delay are often made by a shop against an inspector, but as a rule it is due primarily to faulty workmanship, which the inspector has not allowed to pass without correction; these delays are naturally aggravating to the shop, especially when a time limit is set on the completion of the work, but the fault is not with the inspector; delays are not to *his* liking; as the price for inspection is paid by the ton, the quicker the job is completed the greater will be his profit.

Fourth. That the work of inspection is not effective because often carelessly done, and the price paid for it is thrown away. Unfortunately, this has been but too true in the past: inspectors did their work carelessly, many mistakes were overlooked and inspection was in many cases more of a farce than a benefit; and to-day many jobs of inspection are taken and performed in a similar way, for they are taken at a figure so absurdly low that the inspector can afford to give them only the most meager attention; the work is handled so as not to lose money on a contract, regardless of the employer's interests. Tales of carloads of material that have been shipped and never seen by the inspector are not very convincing as to the value of inspection, but an engineer should be just as careful in the choice of his inspectors as he is to see that his work is inspected. There are a few bureaus which are striving for the improvement of inspection service by means of establishing a careful system for the thorough handling of the work and employment of only reliable men; and such bureaus *can,* and *do,* give the quality of work that renders inspection valuable. Their greatest difficulty is to secure the work, in competition with the smaller inspectors, who agree to take the same work at a ridiculously low price, without any idea of doing it properly; and here architects and engineers are to blame when they do not distinguish between qualities of inspection, and too often let the work to the firm that will do it at the lowest figure, regardless of their facilities or reputation; these are the engineers and architects who cry so loudly at the inefficiency of inspection. The old rule that "what a man pays for, that he will get," is quite universal in its application, and is no exception when it comes to inspection. If good inspection is desired, then good inspection must be paid for, and it is only good inspection that is valuable.

Fifth. That the price of inspection is too high. As to the price at which good inspection can be done, the following may be said: About six years ago one of the most experienced bridge

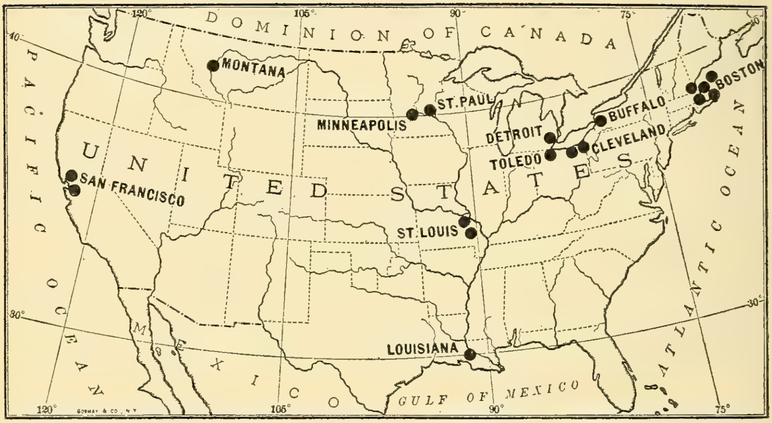
engineers of this country, Mr. J. A. L. Waddell, submitted to several inspection bureaus a set of instructions to inspectors at mills and shops in which was incorporated his own idea of what thorough inspection should consist, with a request for bids on the inspection of a large order of structural steel under these rules and with his specifications. The bids received varied from $1 to $1.25 per ton of 2000 pounds, and Mr. Waddell found, in subsequent experience, that the inspection he called for was worth $1 per ton for large orders and slightly more for smaller ones, where greater expense in proportion to the output of the shop was entailed; however, it is very seldom that such a price is paid in this country for inspection. One acquainted with this particular set of bridge specifications knows it is one of the most thoroughly rigid sets of specifications under which bridge work is done, and of all of the prices at which inspection in mill and shop is taken, varying from 35 cents to $1 per ton, whether taken under specifications as rigid as these or less, the quality of the work performed will be according to the price paid.

At times, and under specially favorable conditions as regards the location of a bureau's employees, it can be done for less than $1 a ton. On small jobs it may be more, but there is, in general, a chance for the inspector to make a fair living at that average price. In consideration of what engineers and architects receive for their services, is from 1½ to 2 per cent. too high a price to pay for inspection of a structure in shop, mill and field? Is it too high a rate of premium to pay for security? The question, Does inspection pay? then is answered: whether you want *good* inspection at a cheap price or are satisfied with *poor* inspection at a cheap price, the latter is what you will get. On the other hand, if you are willing to pay a *reasonable* price you *can* get good inspection, and only good inspection pays. The most experienced architects and engineers already realize that only first-class inspection is valuable. They are taking pains to see that only first-class men are employed at a fair price. Inspection bureaus who enjoy the patronage of such men are doing all their work the best they know how, and are fondly hoping for the dawn of the day when the general public will recognize the value of the efficient service so rendered.

Much of the success or failure of inspection depends on the individual ability and character of the inspector. Good inspectors are not easy to find, and, when found, they are worth more than the cheap bureaus can afford to pay them. A successful inspector must have a rare combination of good qualities. He must be a

practical man, with long training in mills and shops. He must thoroughly understand all the details of the various processes employed and what are the various faults that are liable to result from each process. He must so well understand these faults as to be able to detect them at once, and he must be so well informed as to know how best to correct them in the most practical manner, and when correction is not possible. But experience in mill and shop practice alone will not suffice; he must also understand enough of structural engineering to recognize the relative advantages of different details and designs; he must be able to figure out the strength of the various connections and parts, and have accurate judgment to determine just what effect a loose rivet here or a bad fit there may have in the resulting structure; he must, withal, be a good deal of a diplomat. The inspector who cannot deal with each mill and shop foreman in the way to best command his respect and secure his co-operation will never make a success.

The inspector's life is not all sunshine; he has many a disagreeable duty, and, unless he has the necessary judgment and diplomacy, there will be much friction between him and the men in charge of the mills and shops where his work is located. But a good, sensible man, with the qualities of a good inspector, will gain his points without engendering bad feeling; will get over the rough places tactfully, and do his work quietly and unostentatiously, but effectively. Some day the public will appreciate how important his work is, and then the inspector and the inspection business will receive the respect it deserves.



MAP

Showing the locations of the Societies forming

THE ASSOCIATION OF ENGINEERING SOCIETIES.

(Each dot represents a membership of one hundred, or fraction thereof over fifty.)

Editors reprinting articles from this journal are requested to credit not only the JOURNAL, but also the Society before which such articles were read.

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ARGENTINE: PAST, PRESENT, FUTURE.

BY ELMER L. CORTHELL, MEMBER OF THE BOSTON SOCIETY OF CIVIL ENGINEERS.

[Read before that Society, December 17, 1902, and before the Detroit Engineering Society, April 3, 1903.*]

IN 1899 the Argentine Government, having conceived an extensive project of river and harbor improvement, and made the preliminary surveys, requested the United States Government to recommend an engineer who would come to Argentine and assist the Government by his advice in forming and executing the plans.

I had the honor of being selected for this position. After carrying out a two years' contract with that Government, I have returned to my own country with some knowledge of the conditions and some experience in meeting them. These form the basis of this lecture.

At the final general session of the International Navigation Congress at Düsseldorf, July 4th, this last year, when called upon to respond for the Argentine Republic, I used the following words:

"It may not be out of place to make a few comparisons between the two countries which, by a singular coincidence, I have the honor to represent—one as a delegate to this Congress; the other as a member of the Permanent International Commission. One of these countries is the Argentine Republic and the other the United States of North America.

"Both are cosmopolitan; both have been populated largely from Europe; both had the task of supplanting savagery by civilization. The red races in each case had to give way to the Caucasian, or be assimilated with it. Both have great plains and im-

* Manuscript received March 14, 1904.—Secretary, Ass'n of Eng. Socs.

mense river systems. The greatest river valley of the one is almost exactly equal to that of the other. Similar causes have produced nearly similar hydraulic conditions in each case. Both countries have temperate climates; both, great mountain ranges; both, some extent of arid lands and running waters for irrigation; both, immense areas of rich soils, made so by similar beneficent causes; both have extensive pasture lands and millions of cattle, sheep and horses. In their cereals they are competitors with each other in the food markets of Europe—one is great and ambitious, the other smaller but earnestly devoted to progress and ambitious to fulfill its high destiny among the nations of the earth."

By comparisons of the unknown with the known we appreciate and learn, and for that reason I shall compare Argentine with the United States in respect to some of its more important features, and you will see that the two great countries have much in common.

You must, if possible, imagine yourselves in a situation exactly opposite from yours in the United States in regard to the sun and the poles of the earth; you must look north for warm winds and south for cold ones. Your winter will begin in June and your summer in December. The north side of your house will be sunny and the south side in the shade. As you travel north from Buenos Aires, the capital, it will grow warmer; as you go south you will at last reach the glaciers. Your north star will be changed to the Southern Cross, and in all these changes you will at first be lost. You must also locate yourself geographically, and recollect that the northern line of Argentine is in about the same latitude south of the equator as Havana is north of it, and that the southern limit of Argentine corresponds to Labrador and Kamchatka, and that Buenos Aires, Capetown and Melbourne are all in about the same latitude; also, that there are east and west differences. Buenos Aires is in about the same longitude as Cape Breton Island, east of Nova Scotia, and the circle of longitude along the most westerly boundary of Argentine nearly passes through Boston; and the course from the entrance of the River Plata to Liverpool is nearly a straight line. In order that the location of Argentine in reference to other South American countries may be appreciated, it should be stated that Buenos Aires is as far south of, say, Caracas, the present center of revolutionary and unstable South America, as the north end of Lake Winnipeg, in Manitoba, is north of Caracas, or as far as the northern part of Greenland is north of New Orleans.

With this orientation of ourselves on the western hemisphere, and with these remarkable differences in position, let me call your

attention to a very remarkable similarity wherein will be seen and appreciated the beneficent work of the Great Creator long before at least the present race of mankind inhabited the two continents.

In a paper read before the American Association for the Advancement of Science, at Buffalo, August 5, 1896, upon the delta of the Mississippi, I described the ancient conditions of that great river in substance as follows:

First, a deep shore line of the Gulf of Mexico, when the site of Galveston was far out in the waters and the coast was 100 miles inland from the site of New Orelans—a wide and deep estuary 1000 miles long, reaching into the heart of the continent to between St. Louis and Cairo, where, at Cape Giradeau, it met the ridge of the Ozark Mountains, stretching across the valley and holding back the ancient great lake, which covered Chicago 200 feet deep and spread over all the great prairie States and received and distributed over its bed the immense sediments of the Missouri and other great rivers in the North. Then came the cyclic change, lifting Florida out of the water and turning continental drainage north, cutting its way through the alluvion to Hudson Bay. Then the breaking down of the Ozark barrier; the draining of the submerged area; the subsequent filling of the estuary and the advance of the alluvial lands into the gulf to their present line, 110 miles beyond New Orleans. A great and wonderful beneficence for the use and convenience of man by the Great Architect of the Universe.

Had not my engineering experience upon the Mississippi River and its delta drawn my attention to this extremely interesting ancient history of the great river of North America, I might not have been so deeply impressed by its remarkable similarity with that of the Paraná River in South America; and for both histories I am indebted to engineering investigators—General Warren, in the first instance, and Colonel George Earl Church, an American engineer living in London, in the second instance, the latter probably better acquainted by personal contact with the geography and hydraulics of South America than any other living man.

I am indebted to him and the Royal Geographical Society, of which he is a director and correspondent, for most of what follows in relation to this *ancient* history of the great rivers of Argentine and Central South America.

There are four great breaks in the mountain-fringed continent which we call its great commercial doorways: the Orinoco, the Amazon, the La Plata and the deep indentation of Bahia Blanca—one in Venezuela, one in Brazil and two in Argentine. The three river basins occupy two-thirds of the entire area of South America.

The two with which we are most interested in this lecture are the La Plata and Amazon, which have areas, respectively, of about 1,200,000 and 2,722,000 square miles. But if we deduct from the latter the valley of the Tocantins, which has no direct connection with it, the valley of the Amazon is 2,368,000 square miles; its principal branch, the Madeira, has a volume of discharge nearly equal to the Amazon itself, and at the falls, which I shall refer to later, it carries annually a volume equal to that of the La Plata, which has a minimum flow of about 534,000 cubic feet per second and a maximum of over 2,000,000—a river 80 per cent. larger than the Mississippi, "the Father of Waters," if we compare their mean annual discharges, the former being about 288 cubic miles and the latter 156 cubic miles. The Paraná ("the mother of the sea" in Indian language), the principal affluent of the La Plata, is itself 46 per cent. larger than the Mississippi, its mean annual discharge being about 230 cubic miles.

What a river the La Plata must have been in ancient times, when it had a maximum discharge of 4,000,000 cubic feet per second, well up toward the modern Amazon, estimated to be 5,297,000, and greater than the ancient Amazon!

I have described the ancient conditions of the Mississippi—the Gulf of Mexico as a great estuary and a deep shore line extending well into the heart of the North American Continent. The same conditions existed in the contour line of South America in the La Plata estuary. It extended 1400 miles into the Continent, and was 400 miles wide—eleven times greater than the Empire State. It was the great "Pampean Sea," receiving the drainage not only of the present Paraná and its tributaries, but of the great Madeira River, with its immense discharge of waters and sedimentary matters—the source of great alluvial formations, discharging into a sea two-thirds the size of the Mediterranean.

When, in the processes of nature, the great underwater plains of rich soil had been formed during the comparatively short period of less than 100,000 years, a dam was thrown across the Madeira by the Rivers Grande and the Parapití coming down from the Andes, and a deposit more than 170 feet deep occurred, forming this dam, which produced the ancient Lake Mojos, with an area of about 115,000 square miles, larger than that of the Great Lakes of North America combined, which is less than 94,000 square miles.

During this process the ancient lake and the Pampean Sea were connected, and their relation was similar to that of the Black Sea and the Mediterranean. Traces of it are still observable, notably the great, low, flooded morass of Xarayas, on the upper

Paraguay River, and the ancient delta of the Paraná, including the Ybará lagoon. The Salina Grande was also an arm of it—a great inland fiord. The sea, moreover, must have covered large areas of Paraguay, Corrientes, Entre Rios and Uruguay, and, before the uplifting of the country, it extended southwest to the rivers Chadi-Leofu and the Colorado, lapping around the southern slope of the Ventana range, until the curved rim, concave to the northeast, which connects this with the Sierra de Cordova, was sufficiently elevated to completely cut off its southwestern extension.

This range was high enough to lodge the glacial rocks coming from the Andes, one of which at Tandil is so poised and delicately balanced that the hand can rock it, but it cannot be dislodged. This range later prevented the entrance of the destructive sea, protecting the great area from its waves.

Then came another factor into the beneficent problem of the Creator. Instead of draining the waters from the great deposits under the Pampean Sea, as He did in North America, He lifted the Andes higher, and with them their Atlantic slopes, until the latter were ultimately lifted to their present level, forming the "plains of the pampas," the soil of which is 50 feet deep and of surpassing richness—an area of 600,000 square miles, one-fifth the size of the United States and five times that of Great Britain. Thus by cyclic changes in the northern hemisphere, and by fluvial and sedimentary action and seismic changes in the southern hemisphere, have been formed the great interior agricultural regions of the United States and Argentina.

In order to give an idea of the size of the Paraná River, it may be stated that its annual flow is double that of the Ganges, three times that of the St. Lawrence, four times that of the Danube and five times that of the Nile. We have records of *608 cubic miles* in one year.

There are differing conditions of importance between the Paraná and the Mississippi, explaining the causes of the greater discharge of the Paraná. While they both flow south, one flows from colder to warmer and the other from warmer to colder regions; and it is in the warmer regions in both cases that the rainfall is the greater. On the Mississippi, in the northern regions, where we find the greatest drainage area, the rainfall is about 35 inches per annum; in the southern, where the area is less, the rainfall is 60 inches per annum. With the Paraná there is a rainfall of about 60 inches in the northern part, where the drainage area is greater, and about 40 inches in the southern part, where it is less.

The length of the Paraná River is about 3000 miles; its naviga-

ble length, between Cuyabá in the north and the mouth of the Paraná in the delta of the La Plata, is 1825 miles. The Uruguay River, from San Javier to the delta of the La Plata, has a navigable length of 603 miles. The Paraná River is made up of the two important rivers which unite at the city of Corrientes—the Paraguay and the Alto Paraná. The length of the latter above Corrientes, to the falls of the Yguazú, is 365 miles, and it is navigable nearly to that point. These wondrous falls excel in beauty, as well as exceed in dimensions, the Niagara Falls.

The latter are 160 feet high, as a maximum, and $\frac{4}{5}$ of a mile long, including Goat Island. The Yguazú are 213 feet high in one leap and 106 feet in two leaps, and $2\frac{1}{3}$ miles long, with, at times, an immense volume of water.

The view before you is from a painting by a well-known Bern painter, Mr. Methfessel, who was engaged to come to Argentine, visit the falls and make a large painting for the La Plata Museum.

The gorgeous and varicolored foliage of the luxuriant subtropical vegetation, which abounds on all sides, adds a charm to the falls. They rank among the most beautiful and wonderful works of the Creator.

The Uruguay is an entirely different river, in every respect, from the Paraná. It is, at times, a mighty river, rivaling the Paraná; at others it sinks into comparative insignificance. The Paraná is a great river at all times.

The Paraná is a type of a truly great river; the Uruguay represents a mighty torrent of extraordinary dimensions.

The Uruguay rises near the Atlantic seaboard in Brazil, in the Sierra del Mar, then runs west to the highland of the Territory of Misiones. These highlands prevent it from uniting with the Alto Paraná River at that point, which is only about 68 miles distant. Along 600 miles of its course from San Javier to Concordia the bed of the river is filled with rocky ridges, which, at low water, prevent continuous navigation, but during the floods, which are quite sudden but not long continued, the river is everywhere navigable. The river rises, in floods, at Concordia about 46 feet. Compared with the Paraná, it is a clear stream, carrying very little sediment in suspension. The Paraná is an entirely different river. Its source being in the tropical and rainy region of Brazil, on the flanks of the Andes, its floods are much longer continued. At the confluence of the Paraná and the Alto Paraná at Corrientes, the rise of the floods is about 33 feet; at Rosario, 225 miles above Buenos Aires, it is from 19.7 to 23 feet or $23\frac{1}{2}$ feet in extreme floods. When these occur, the river is about 23 miles wide, cover-

ing the entire country with a depth of 6 to 10 feet, and extending to the highlands of the Province of Entre Rios.

The physical characteristics of the bed of the river are, consequently, entirely different from those of the Uruguay; the bed of the latter is stable, that of the former very unstable. The sedimentary matters carried in suspension, however, are very much less than those of the Mississippi; probably only one-tenth of the amount carried in the Mississippi in times of flood. For this reason the changes in the bed and banks are less radical; the most noticeable change is the movement of the islands and bars down stream. For example, the island of Espinillo, in front of the city of Rosario, lying in the middle of the river and about 2½ miles long, has moved, flanking, down stream about 2½ miles in the last 50 years, and by this movement the advancing bar of the island has approached the river bank in front of Rosario and closed up the navigation channel.

The maximum velocity in great floods often reaches 6½ feet per second, although usually it is much less, equal to that of the lower Mississippi.

Both rivers are susceptible of improvement by dredging, the one to Asunción, which is 842 miles above the mouth, and the second to Concordia, which is 230 miles above its mouth. In the Paraná there is nothing but sand to be removed throughout its entire length; in the Uruguay there are several places where it is necessary to remove rock and gravel. But, generally, the channel can be deepened by hydraulic, or suction, dredging.

The National Government is under obligation, by the law passed by Congress for building the port of Rosario, to make and maintain a depth of 21 feet at low water in the Paraná River from the head of the delta to Rosario, and in the delta of the La Plata to Buenos Aires a depth of 19 feet at low water, which is about 21 feet at mean high tide. It has been proposed to make and maintain a channel of the following dimensions: From the mouth of the two rivers, at the island of Mártin Garcia, at the head of the La Plata estuary, to Rosario, a depth of 21 feet and a width of 328 feet; Rosario to Santa Fé, 292 miles above Martin Garcia, 19 feet deep and 328 feet wide; Santa Fé to Corrientes, 10 feet deep, and the same depth to Asunción. Santa Fé, or its seaport Colastiné, is the head of ocean navigation; above that point it is river navigation by steamboats.

On the Uruguay River it is proposed to make a channel 19 feet deep and 328 feet wide, from Martin Garcia to Conception del Uruguay, 137 miles above Martin Garcia, and thence 15 feet deep

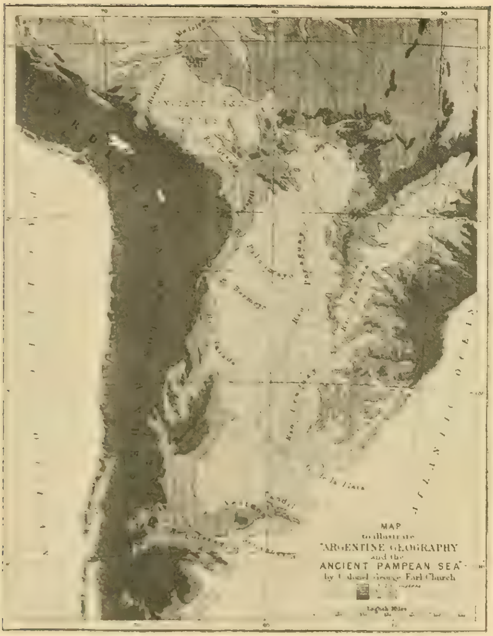
to Colon, and 9 feet deep and 8 feet over the rock to Concordia, which is 230 miles above Martin Garcia.

The low-water plane, or zero, in both rivers is that of extraordinary low water, so that, generally, the low water does not reach this plane within about half a meter to one meter. Consequently, there can generally be depended upon from 2 to 3 feet more water than I have stated. Between Rosario and Buenos Aires there are now no bars over which there is not 21 feet of water at zero, although two of them need to be dredged and buoyed in order to make a straighter channel. This the Government is prepared to do.

As to the port of Rosario, a contract has recently been made, under the law of Congress, to make a modern seaport at this point, with all the latest and best facilities for handling cargo. The commerce of Rosario is at present 1,500,000 freight tons per annum. It is a very important exporting point for cereals, and when the port is completed according to the plans adopted, it is expected to be an important importing port as well. There are ports below Rosario, such as Villa Constitución, San Nicolas and San Pedro, and above Rosario, Diamante, Santa Fé, Colastiné and Paraná. On the Uruguay River, Concordia, at the head of steamboat navigation, is an important importing and exporting port for that section of the country. Its registered tonnage is about 500,000 tons, and the actual weight tonnage about 100,000 tons.

The country between the Paraná and Uruguay Rivers is practically isolated from the rest of the country, and its situation is very similar to the country lying between the Euphrates and the Tigris; for that reason it has been called the *"Mesopotamia Argentina."*

There are at present in this area three railroad systems—the Argentine Northeastern, which runs from Corrientes, on the Paraná, to Monte Caseros, on the Uruguay, and from there to Santo Tomé, on the same river; the Argentine Eastern, from Monte Caseros to Concordia, and the Entre Rios Railroads, the main line of which connects Paraná and Conception del Uruguay, with branches to Victoria, Gualeguay, Gualeguaychú and Villaguay. Within a few months a connecting line will be completed to Concordia, forming a link between the Argentine Eastern and the Entre Rios systems. It has been proposed to unite these three systems and to extend the Argentine Northeastern from Santo Tomé to Posadas, on the Alto Paraná, passing through the colonies which the Government is establishing in that Territory. Posadas is its capital. The Central Paraguay Railroad, which runs in a southeasterly direction from Asunción, it is proposed to extend to Villa



ANCIENT PAMPEAN SEA AND LAKE MOJOS.

FALLS OF Y-GUAZÚ.

Paraná River from Grain Elevator at Rosario.

La Plata Superior and Delta of Paraná

Encarnación, a small town on the opposite side of the river from Posadas; to change the gauge, which is 5½ feet, to the normal gauge of the other three railroads, which is 4 feet 8½ inches; make a transfer by car float at Posadas; extend the Entre Rios Railroads to a port of deep water, either on the Paraná or Uruguay, and do a "through" business between Asunción and this new seaport, which will be only a few hours distant from Buenos Aires.

With the Paraná River improved to Asunción and the Uruguay improved to Concordia; with the railway systems united and extended to a good seaport, this great interior district of the country will have an ideal system of transportation, and the shipper may take his choice, to ship by rail or by water, thus establishing a very useful and reasonable competition between water and railway, to the great advantage of the people.

In reference to the Rio de la Plata itself, it is an immense shoal estuary. It is the depositing ground of the great Paraná River. This estuary, in a not very remote period, extended above Santa Fé; this is shown by the comparison of old maps, of which 92 have been collected and copied and placed in the library of the Ministry of Public Works. These maps date from the year 1529 to 1885. Even in this comparatively short period, remarkable changes are shown in the delta of the Paraná, which is now a true delta, almost exactly in the form of the Greek letter Δ. It is 40 miles across its face; it slowly extends itself in the head of the estuary, and through the delta nearly a dozen outlets of the Paraná River find their way. It is very much like the deltas of the Danube, Ganges and Mississippi.

The superficial extension of the Rio de la Plata exceeds 18,000 square miles; it is about 186 miles long, and varies in width from 186 miles at the ocean, between Capes San Antonio and Santa Maria, to 1.12 miles at the extreme point of the head of the estuary, at Punta Gorda.

To understand the physical conditions of the estuary, it is necessary to divide the Rio de la Plata into superior and inferior, or upper and lower. The Rio de la Plata superior lies above a line extending between La Plata and Colonia, the inferior below that line to the sea. Over a distance of about 25 to 30 miles between Martin Garcia and the anchorage of Buenos Aires there is a normal depth through the best channels of from 16 to 20 feet at low water.

The National Government has recently completed the dredging over the San Pedro bar lying in this region, increasing the depth of 18½ feet to 21 feet, where there was formerly only 15 feet. In the Canal de las Limetas, or Nuevo Canal, by natural forces and

by the constant movement of steamers, there has been obtained a depth of about $19\frac{1}{2}$ feet, or $21\frac{1}{2}$ feet at mean high tide. Opposite Farallon, a rocky point on the Uruguay shore and opposite Buenos Aires, there is, along the course of navigation, about $19\frac{1}{2}$ feet at low water. The Government has buoyed with luminous buoys the entire route from Buenos Aires to the mouths of the Paraná River, the Bravo and the Guazú, and has placed a floating semaphore below Martin Garcia for the benefit of navigation, recording constantly by signals by day and by night the depth of water in the channel. It is now proposing to connect this semaphore by a telephone cable with the telegraph cable of Martin Garcia, so that communication may be established between the ships lying at anchor (waiting for the tide, or passing near the semaphore) and the offices of the agents at Buenos Aires or Montevideo.

A careful study of the different conditions in the delta of the La Plata shows that the only method of improvement in such a vast expanse of water is by dredging and buoying the best channels.

In the lower Rio de la Plata there are very serious conditions. A bar on which there is a least depth of 20 feet at low tide lies between the anchorage of Buenos Aires and Montevideo; the material in this bar is very soft and vessels plough their way through it on ordinary tides, but the great extent of the bar is the serious condition. Between the 24-foot curves, straight through this bar, there is a distance of 24 sea miles. To make a channel by dredging would require the removal of probably 10,500,000 to 13,000,000 cubic yards; and it is very doubtful if, on such broad extension of water and in such soft material, a channel could be maintained. But it is hoped that the plan now proposed of anchoring five lightships in the line of navigation, and in the direction of the current, and which can be seen from each other, will have an effect upon the bar by the continued movement of deep steamers through it. The examination of the Rio de la Plata inferior has been intrusted by the Government to the Ministry of Marine, which is making very extensive surveys and examinations over the entire area.

The estuary at this point is 46 miles wide, and five high towers on shore and others anchored within the area to be surveyed are necessary in order to cover this great Punto Indio bank.

These are the general physical conditions of the Rio de la Plata and its great tributaries.

In addition to the great drainage basin of the La Plata, there are further south, the large rivers, Rio Negro and Colorado, which, combined, have a drainage area of 464,000 square miles. The

channels are not susceptible of improvement for a large commerce, but they will in the future furnish water for an extensive irrigation and steamboat navigation.

The hydraulic conditions are great, but the mountains are greater, and have exerted a powerful influence on the continent, not only upon its climate and its running waters, but upon mankind. On these lofty table-lands lived the Incas and flourished their great empires. Among the clouds have fought for supremacy the Incas' troops and the Spanish soldiers, and here, too, have the struggles for liberty taken place; here Bolivar and San Martin led their troops to victory and continental freedom from the domination of Spain.

An orthographic map of South America will show what immense areas are given up to mountain ranges and lofty summits. In their widest part the Andes are 500 miles in breadth. Some mighty force seems to have pushed them and the entire continental line eastward and massed the ranges into a complex system of mountains, towering isolated peaks and parallel, transverse and interlaced ridges without number. In Bolivia, not far north of the country we are describing, there are thirty-two peaks above 17,000 feet high, some of them reaching over 21,000 feet; and in Argentine is the lofty Aconcagua, lifting its solitary crown to an elevation of 23,080 feet, rivaling the loftiest mountains of the world. And Famatina, in the Argentine Province of Rioja, rises to 20,680 feet, and the grand mountain Tupungato 22,015 feet high.

Between Argentine and Chili, between latitude 23 and 35 degrees, the mountain passes, which are from 10,000 to 14,000 feet high, are blocked with snow from May to August, and they are swept by violent storms.

The height of the passes, all the way from 7 to 37 degrees south latitude, Northern Peru to Southern Argentine, shows the determination of nature to oppose transit by man, piling up in his pathway these almost insurmountable obstacles. When it is considered that this immense barrier covers a sixth part of the circumference of the globe, its influence upon the development of the Continent is apparent.

It is unnecessary to go into the history of the South American Republics. Their origin and development are easily found in any good American library. But it may not be generally known that, from the first arrival of the Spanish adventurers to the successful end of the great struggle for liberty in South America, there was always dissatisfaction, unrest and hatred of the conquering race. The seeds were sown in bloodshed, in the persecution by the In-

quisition and in false commercial and governing methods of Spain and Portugal, the mother countries. The difference between North and South America in this respect was very great.

It is a significant and curious fact in the history of South America that, during the entire eighteenth century, the same causes were producing the same effects among people far separated from each other and of a character entirely distinct, scattered from the banks of the Paraguay River to the Colombian Mountains.

Those effects may have been the precursors of that great revolutionary movement that created our great Republic and drove the Bourbons from the throne of France, and, later, shook to the center the monarchical fabric of Spain herself.

We may, therefore, say that the struggle and the preparation of the ground for civil and religious liberty began earlier in South America than in North America. In the British Colonies there was no strong sentiment against foreign rule until the imposition of the taxes required to furnish George the Third with revenue to pay off his debt of 148,000,000 pounds sterling. Even Washington, in July, 1775, when he took command of the Continental army, declared that the idea of independence was repugnant to him. Only later, and soon, when the war was suddenly upon the Colonies, did events hasten and make inevitable the separation from the mother country.

It would be a subject of great interest to enter upon—the three great leaders and heroes of American revolutions—

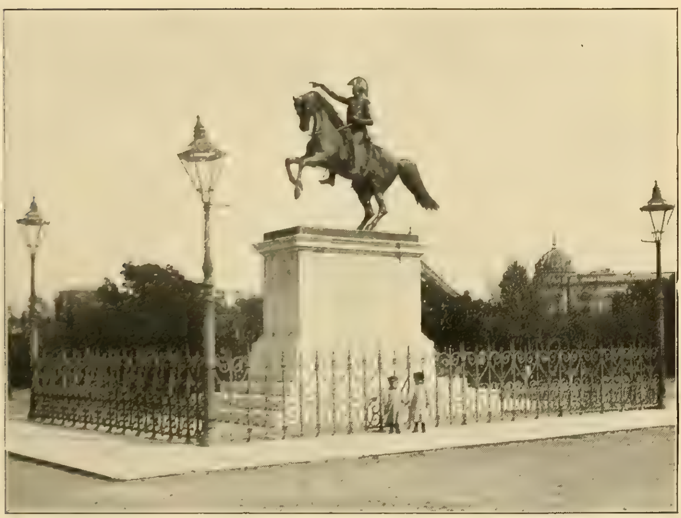
WASHINGTON—BOLIVAR—SAN MARTIN,

a triumvirate of liberators.

Of the two former you already know much, possibly of the latter, but you may not know that it was by his patriotism and generalship that the whole of Southern South America was freed from the yoke of Spain—Argentine, Chili, Peru and Bolivia. His biography is a romance of most absorbing interest.

Born in 1778, in Argentine, in Japeyú, he received his early education in Buenos Aires; completed it in Spain; served with distinction and great bravery in the wars of Spain. Early he was imbued with the doctrine of liberty for his native country; spent a year in Great Britain in 1811, forming associations and a secret league devoted to the liberation of Argentine. Landed in Buenos Aires in 1812; soon in command of a regiment of Grenadiers; selected soldier by soldier, officer by officer; imposed the most rigid discipline, so forming a rudimentary school for a generation of heroes that followed him, and producing nineteen generals and nearly all the great

Orographic Map of South America.



Statue of General San Martin.

View in the Cordilleras.

Plaza Victoria and Statue of General Belgrano.

men of the struggle for independence. Placed in command of the army to reorganize it, he marched to Mendoza, the nearest point to the Andes, and, imbued with the idea that no liberty would be secure for his country until the Spanish armies were beaten and expelled from Chili, Peru, Bolivia and the whole of South America, he formed his plans for an invasion of Chili. He was the very incarnation of determined patriotism; nothing, not even revolutions and discord behind him in his own country, could deter him from his great work. At this moment Napoleon fell, and Spain prepared an expedition of 15,000 men destined for the Rio de la Plata. In Chili and Peru the Royalists were victorious; but in Argentine on the 9th day of July, 1816, at Tucuman, the declaration of independence was proclaimed, which, like our own, is sacred in the heart of every Argentine.

In the midst of these great and momentous events, San Martin recruited and drilled and clothed and provisioned his little army destined to conquer a continent, to scale high mountain passes and pour down upon an enemy largely outnumbering his own. He ostensibly made roads over certain passes and, when all was ready, led his army over another and very different pass and came down upon his foe and defeated him in Chacabuco; and again on the plains of Maipú routing the enemy completely and assuring the independence of Chili. Then, though anarchy was reigning in Argentine and his Government was calling upon him to return, his fixed and irresistible purpose of dealing the final blow to Spanish authority in Peru pushed him forward. With a fleet hastily gotten together and commanded by Lord Cochrane, and with English and United States officers in command of the ships, he sailed from Valparaiso with his troops up the coast in December, 1818. He had only 4430 men, Argentines and Chilians. The Viceroy of Peru had 23,000 soldiers awaiting this little army. On July 28, 1821, as a result of his campaign, the independence of Peru was proclaimed in Lima, and San Martin made dictator. In the meantime, General Bolivar, after liberating Venezuela and Colombia, reached Quito, and his forces, united with an Argentine division, routed the Spanish army in the battle of Pichincha; and then he hastened on to Guayaquil, anxious to finish by himself the Peruvian campaign. Here let me quote a paragraph from the history of Argentine by the Hon. Martin Garcia Mérou, the Argentine Minister at Washington.

"There he went to find San Martin, whose purity of character and noble unselfishness formed a marked contrast with the impetuous ambitions of his glorious rival. The two liberators had

a conference July 26, 1822, the details of which were kept secret; but it is a well-known fact that San Martin comprehended that, in order to accomplish South American independence and avoid the scandal to the world of a break with Bolivar, caused by the latter's thirst for glory, it would be best for him to depart from a scene where his great presence had no place."

The story of self-abnegation and the rest of his life is told in a word. He resigned the dictatorship of Peru; passed to Chili, to Mendoza, to Buenos Aires, to Europe, where he resided four years in Brussels on a very modest pension. Once more, in 1829, he returned to the La Plata, stopping at Montevideo; but, learning that anarchy prevailed in his own country and deaf to the entreaties of his friends to come to their help, he took a steamer back to Europe, saying, "No, General San Martin will never spill the blood of his fellow-citizens; he will draw the sword only against the enemies of America." And, without even seeing Buenos Aires, he sailed for the last time to his voluntary exile, dying suddenly August 19, 1850. He was free from those theatrical qualities which appeal to the multitude. In this great character predominated those moral qualities which entitle San Martin to a prominent place in South American history. Inflexible in the discharge of duty, a rigid disciplinarian, everything was subordinated to the high mission to which he had devoted himself, and he never sacrificed his cause to ambitious or personal vainglory. *He was the incarnation of an idea.* His modesty, his pure and elevated character, the simplicity of his life and the nobility of his principles give him rightfully a position by the side of the great heroes of history.

In the vicissitudes of the epoch under consideration, when European wars and the disasters of nations reflected themselves directly and indirectly upon the people of the River Plate and led slowly to the formation of the Republics of Uruguay, Argentine and Paraguay, many notable and great men, as well as despots and bloody tyrants and political demagogues, appeared upon the scene and the pages of history. No name more illustrious, contemporaneous with San Martin, is seen in the records of that time; more brilliant and more important in results than that of General Belgrano. His generalship, diplomacy, statesmanship and exalted patriotism give him a most distinguished position in the annals of independence; as General Mitre has well said in the opening sentence of his "History of Belgrano," "this book is at the same time the biography of a man and the history of an epoch." His statue is before us as we stand in the archway of the National Govern-

ment Building and look out upon the beautiful Plaza Victoria. General Belgrano was really the author of the national flag. The white and the blue are the colors of the Patricios, the regiment of native Americans, at the time of the overthrow of the Spanish Viceroy, on the 25th of May, 1810.

Coming to later times, new and illustrious names appear—men who were true patriots, who would not stoop to fraud or unbecoming political act, and who, amid the errors of their time and the temptations to do evil, came out pure as gold tried in the fire. One of these men is the author of the "History of Belgrano"—General Mitre, still living,—the general who led the forces of Buenos Aires in the last struggle for a united republic, and who may be called the Father of his Country; for under his wise governorship, his skillful generalship and wisdom as President, Senator and a public man always before the people, the country has been strong, united, prosperous and peaceful.

The sincerity of his motives, the purity of his life, public and private, his self-abnegation, his rigid honesty, his lofty ideas of public office, administering it always as a public trust, his modest and simple life, all explains why the entire nation recently honored his 80th birthday, and why the statesmen of the Republic sit at his feet to learn and to follow his wise counsel.

I have refrained from developing the political history of the Republic or giving its earlier history—the discovery of the River Plate by de Solis, in 1515, giving the name of his second officer, Martin Garcia, to the now well-known island at the head of the estuary; or the discovery, in 1526, of the Paraná River, by Sebastian Cabot, and all the subsequent and checkered history of the Spanish Portuguese rule in the River Plate countries. That they have passed through many trying periods, when the patriotism of the leaders has been severely tested, goes without saying. The heterogeneous elements, the ambitions of designing men, the lack of integrity in the early days of independence and the opportunities which selfish men had easily in their hands to enrich and raise themselves in political station, gave varied and not always envious political changes to decades of Argentine history, not necessary to inflict upon you now. Suffice it to say that the country has passed safely through those terrible ordeals. The principles of the 9th of July, 1816, in the Proclamation of Independence, and those laid down May 25, 1853, in the Constitution of the United Provinces, form the basis of the Republic—fourteen Provinces (States) and ten Gobernaciones (Territories)—principles which all hold sacred and which are almost exactly similar to our own.

The world, and especially its republics, owe more to Buenos Aires than is generally known or recognized. The brief but eloquent summary of this period of its history by General Mitre shows how great has been its influence in the development of American national life.

I stated, in my remarks at Düsseldorf, that the country was ambitious and determined to fulfill its destiny among the nations of the earth. I cannot close the political subject of my lecture without confirming this statement by the words found at the close of Mr. Mérou's "History of Argentine," which he brings down to 1870.

"The Argentine Republic came out of this campaign (1870, with the dictator and tyrant of Paraguay) strengthened and united. The sentiment of nationality, crystallized by common sacrifices, was from that time forth an indestructible fact and a promise of days of prosperity and greatness, of a country united, free and powerful. We can contemplate the problems of the future with tranquillity, consecrating ourselves with all of our intelligence and forces to build up with a broad and generous spirit and a disinterested love for truth and justice (following the traditions received from our forefathers and realizing their noble ideals) one of the greatest, most prosperous and most illustrious nations of the earth."

It is pertinent here to remark that the principle enunciated in 1818, five years before the message of President Monroe, proclaiming the "Monroe Doctrine" with such quiet but firm determination, viz., that *America* is and shall be the undisturbed home of *Americans,* has persisted until the present day, and if attempts have been made at any time to impair the sovereignty of any American nation, there has always been a Grant or a Cleveland to frustrate them. President Roosevelt has recently clearly defined this much-misunderstood principle, or so-called "Monroe Doctrine," when he said: "The nations now existing on the Western Continent must be left to work out their destinies among themselves," and "America, North and South, is no longer to be regarded as the colonizing ground of any European power." Thus it has happened that while the Dark Continent has been partitioned among these powers, no hand as yet has been laid upon any part of America.

Let us now take a bird's-eye view of the present Argentine, a country one-third the size of the United States; a climate salubrious and comfortable; of immense plains formed by nature, as I have already shown, for the use of man—plains where the railroads find no natural obstacles worth mentioning in the way of

their good alignment and construction; where we have, I think, the longest railroad tangent in the world (186 miles), between Junin and La Cautiva, on the Pacific Railroad; plains covered with the cattle of the great estancias, thousands of them of the best breeds in one estancia, and sheep by the millions, and great fields of wheat, corn and linseed, the principal agricultural products of the country. An "estancia" might be called a "ranch" on the great plains of our Western States. Their size varies from about 3000 acres to 700,000 acres; probably 25,000 acres might be considered an average size.

As might be expected of a country stretching through so many degrees of latitude and rising along the circles of longitude from the level of the sea to the highest Andes, there is a great variety of climate and generally an abundant rainfall. Buenos Aires is on the same parallel south of the equator as Wilmington, N. C., is north of it. Snow is almost unknown, and scarcely ever is ice or frost seen. The climate in the summer is tempered with the great body of water of the River Plate.

The rainfall of Buenos Aires averages 35½ inches per annum, about equal to that of the Northern States of the United States. At Asunción, Paraguay, it is 53 inches, about equal to that of New Orleans. The temperature is remarkably uniform. The mean temperature in June and July, 1899, the coldest months, was 54 degrees F., and in January and February, the hottest, 76 degrees, the annual mean being 62 degrees. In twenty years the mean was 63 degrees; summer, 77 degrees; autumn, 65 degrees; winter, 54 degrees, and spring, 63 degrees; mean of January, the warmest month, 79 degrees; of July, the coldest, 52 degrees. The extreme, or extraordinary, limits were 107 degrees, and very rare 104 degrees, frequently 95 degrees, and in winter 23 degrees, which occurred but three or four times. In February, 1900, the heat rose to 103 degrees, but the period of intense heat was only eight days. Such conditions are extremely rare.

The population of the whole country is now about 5,000,000. The wheat area of the Republic, mostly in four Provinces,—Buenos Aires, Santa Fé, Cordoba and Entre Rios,—is about 8,500,000 acres; 80,000,000 to 100,000,000 bushels of wheat are exported. The total area under cultivation in the Republic in 1901 was 17,-500,000 acres. The increase over 1891 was 136 per cent. The crops were: Wheat, 1,964,000 tons; linseed, 490,000 tons; corn, 2,134,000 tons. The total of arable land is 253,000,000 acres, of which 240,000,000 do *not* need irrigation.

In the whole Republic there are 30,000,000 head of cattle,

5,600,000 horses and 120,000,000 sheep (in the United States there are 62,000,000).

As might be expected, the wool industry is very important, about 500,000 bales shipped to Europe being the export product in the years 1901-02—31,000 to the United States and 28,000 to Great Britain.

Argentine is a protectionist country, and its resources for conducting the Government are largely raised from the custom dues. In 1899 the imports free of duty amounted to $14,769,933 (gold), and those subject to duty, $102,080,738 (gold). The exports were $184,917,531 (gold). The United States imports $300,000,000 per annum of sugar, hides, linseed, jute, hemp, wood and fruit, and $36,000,000 of wool and woolen articles. All of these are produced by Argentine, yet only $6,000,000 of the $336,000,000 come from Argentine, or 2 per cent.

The United States export, including cereals, meat and live stock, about $920,000,000, and only $10,000,000 of this go to Argentine, or about 1 per cent., while Argentine's purchases of the same articles in England were $39,000,000, and $60,000,000 from other countries.

Reciprocal trade would open the United States to Argentine wool and treble the production in a few years. There should be direct lines to that country from the United States, and the time should be reduced from about twenty-seven days to fifteen or eighteen days. We should ship to Argentine our manufactures, our coal, pine wood, petroleum, etc., and we should receive from Argentine its wool, hides, grease, dried fruits, hard wood for tanning and dyeing, etc. Now, for want of return freights, steamers load at United States ports for Buenos Aires, and return via Liverpool to New York, frequently via South Africa.

In reference to wool, I have already stated that in the entire United States there are only about 62,000,000 sheep, while there are 120,000,000 in Argentine. It is a well-known fact that the ranges in the far West of the United States, which are absolutely necessary for sheep raising, are rapidly being reduced by the extension of our population westward and the cutting up of great areas into smaller farms. Not only do the smaller farmers, as they go West, wage constant war with the sheep herders, but the cattle raisers do the same; so that the time is sure to come very soon when we will need the wool of Argentine. What this country should do with a great agricultural country like Argentine, capable of immense productions, is to receive its raw materials and ship to it our manufactured goods.

It is proper, in closing this part of the subject, to quote a short paragraph which appears in the "Argentine Year Book," recently published, from the pen of Mr. Ronaldo Tidblom, Chief of the National Department of Agriculture and Live-Stock Industry. In closing up a long and very important article in that year book on the agriculture of Argentine, he makes the following statement:

"Nature has undoubtedly endowed Argentina with advantages for agricultural and pastoral farming not to be found in any other country of the world, and it is not too bold a forecast to say that if the country continues to improve her natural gifts in the same degree in which they have been cared for and improved up to the present time, the day will come when the Argentine farmers will have absolute control of the world's food markets."

Railways have had an extensive development. In 1867 there were 355 miles; in 1880 there were 1563; in 1890, 5862; in 1900, 10,601, of which 1243 belong to the Government and 9358 to foreign companies. In length of line, Argentine stands ninth on the list of countries, but as compared with the United States the mileage is about 5 per cent. The paid-up capital is $550,000,000 (gold). The total receipts in 1900 were $40,000,000 (gold). Comparing the railroads of Argentine with those of the rest of the world, we find that Argentine, in mileage, stands ninth. The length of line per 1000 inhabitants is 3.46 kilometers, while it is 4.86 in the United States, 0.93 in Germany and 1.7 in France.

The Great Southern, the Western and some other lines are still making extensions, and the Southern has crossed the Neuquen River and is looking for a pass to cross the Andes.

There are three gauges—5 feet, which is really the standard; 4 feet 8½ inches, and a narrow gauge, usually about 3 feet 3 inches (1 meter).

The total length of telegraph lines is 28,000 miles, of which 12,000 belong to the Government. Compared with the United States, the Western Union alone has 192,705 miles of poles and cable.

One of the most interesting railroad lines now in construction is the Transandine, which, upon leaving Mendoza, follows the Mendoza River to its source and climbs to the summit of the Pass of the Andes, 3900 meters (13,000 feet) above sea level. The Abt system of adhesion up to 2½ per cent. and then rack to 6 per cent. are employed.

Speaking generally of the railroads, they are well constructed, though good ballast on the great plains is lacking. The cars are like American cars, but the first-class day coaches are much more

luxurious than ours. All the long-distance trains have comfortable sleepers; a buffet and dining car goes with all through trains.

In regard to the industries of the country, while the main products are agricultural and the export as well, important industries are slowly developing. While sugar is an agricultural product, the forty sugar mills may be classed among the industries. In 1870 Argentine imported 22,000 tons, but in 1899 exported 58,000 tons. There are $52,000,000 invested.

The history of the city of Buenos Aires is exceedingly interesting and full of trouble. Founded in 1535, destroyed and rebuilt; and then, from 1650, when there were 400 houses, it grew slowly under the old Spanish régime; and later, under dictators and bad rulers, it slowly advanced in spite of an unstable Government. In 1852, when the noted Rosas was turned out, it had 76,000 inhabitants; in 1864, 140,000; in 1869, 178,000; in 1887, 400,000, and there are at present about 880,000. It is destined to reach the million mark by the year 1906. It is now the largest city in the world, south of Philadelphia, if we except Chinese cities.

Comparing its present rate of growth per decade with some other cities, we find the following: Greater London, 20 per cent.; New York, 37 per cent.; Chicago, 54 per cent.; Philadelphia, 23 per cent.; Greater Berlin, 19 per cent.; Buenos Aires, 40 per cent.

The city is on the right bank of the River Plata, a sloping bank, 50 or 60 feet above the water level, rising up to considerably greater elevations in the center of the city. It is about 120 miles from the sea at Montevideo. Its area is one of the greatest in the world—44,830 acres. Paris has only 19,280; Berlin, 15,625; Hamburg, 15,681, and Vienna, 13,690. It would be a good day's journey to go around the city, as its perimeter measures 39 miles.

As far as the natural conditions permit, the streets are laid out in the form of a chessboard, and are generally about 360 feet apart from center to center. In the central part of the city the streets are narrow; it is difficult for three carriages to pass. There are, however, a few 33 feet wide, and one or two avenues about 100 feet.

The finest and said to be the best-lighted street in the world is the Avenida de Mayo, which is in the center of the city as to the numbering of the houses north and south. It has a fine asphalt pavement and double electric lights in the center. It was cut through the blocks a few years ago from the Casa de Gobierno (Government House), near the port, to the thirteenth street, somewhat less than a mile. At the other end there is being built a beautiful capitol building that will cost about $5,000,000 (gold).

Flock of Sheep.

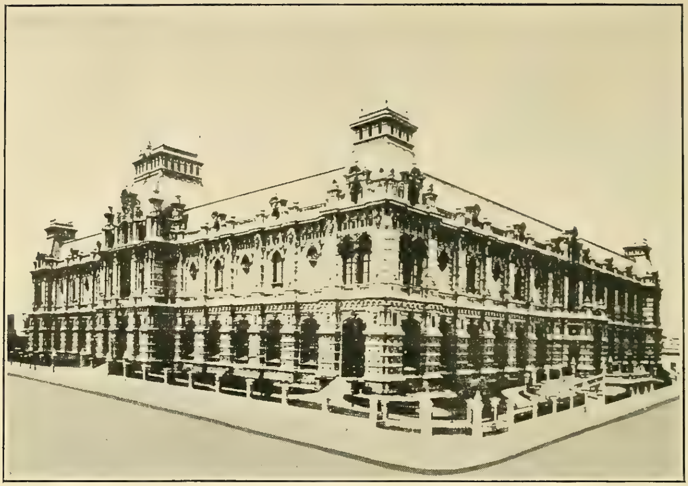
First Tunnel Out of Mendoza.

City of Buenos Aires.

Palacio del Congreso.

Plaza Libertad.

Avenida Alvear.



Distributing Reservoir.

Cathedral.

There are seventy-two parks and small areas outside the main streets, with a combined area of about 1400 acres. These parks are more tastefully laid out and more neatly kept than can be found in any other country in the world, Paris excepted. In fact, in many respects the city, in its streets, lights, parks and structures, resembles Paris, except that there are more one-story residences than in Paris. The prevailing style is Spanish, with a patio (an open area) and the rooms all facing it, and in this patio a garden and fountain, when the proprietor is able to have it; if not, pots of flowers very much like the ordinary city house in Mexico. The style of the houses of the wealthy may be seen on Avenida Alvea.

The pavements are wood (nearly all hard, suitable wood of the country), asphalt, granite blocks, macadam and rubble. No city has better pavements in the central part. In the outskirts, however, much of the pavement is very bad and uneven, merely rubble, but immense sums are being expended in substituting for rubble granite blocks and asphalt.

There is no city anywhere with more lines of street cars; in fact, with the exception of two streets, there is a line in everyone of the principal thoroughfares. And leading out to the pleasant suburban towns, Belgrano, Palermo and Florest, there are electric lines similar to those in American cities, using the overhead trolley. In fact, all the equipment, from rails to trolley, comes from the United States. Very extensive changes are being made in all parts of the city, substituting horse cars for electric. There are now 275 miles of street-car lines, which carried, in 1900, 116,447,982 passengers.

In 1871 there was a terrible epidemic of yellow fever, due, in a large part, to unsanitary conditions; but immediately afterward the city began a very extensive system of water and drainage works, costing $33,000,000 (gold), discharging the sewage 15 miles distant, and the storm waters, by great intercepting sewers now being completed, into the river in front of the city. The city waterworks take their water above the city, where it is never contaminated. These works were designed by Messrs. Bateman and Parsons, engineers, of London, and the main construction was carried out under their supervision.

The water of the River Plata is good, but muddy, and it is clarified in settling basins before being delivered to the distributing reservoir, built on one of the highest points of the city. This distributing reservoir is a work of art, covered with glazed tiles over pressed brick. These works altogether have made Buenos Aires one of the healthiest cities in the world, as the death rate proves.

Ten years ago, upon the completion of the main works, the mortality per 1000 was 30; now it is 16½. This compares very favorably with other large cities. London has 19.2; Glasgow, 21.6; Liverpool, 26.3; Manchester, 24.1; Dublin, 30.4; Paris, 20.1; St. Petersburg, 24.7; Vienna, 20.7; Madrid, 30.1; Rome, 17.6; Venice, 22.8; New York, 19.7; Philadelphia, 17.7; Brussels, 17.9; Boston, 19, and New Orleans (white), 17.9.

The Government is soon to extend the works at a cost of $5,000,000 (gold).

The climate, taking the whole year round, is very equable and very agreeable. The parks are always green; vines and palms and a species of banana plants are seen everywhere, and flowers all the year in the open. It has a semitropical country in the north and in Paraguay from which to procure the plants, where the Victoria Regia and other beautiful plants grow wild.

In reference to education, the primary education is compulsory from the age of 9 to 14; secondary education from 14 to 19 is optional, as also the university, or higher education, from 19 to 25 or 26. No man can enter into any of the professions, including engineering, and take a prominent position in the Government without being a graduate of the National University and having taken the course outlined in the above division of ages.

In 1900 there were 450,000 pupils in the public schools, which are free to all, and free to people of all religions. Although the Catholic religion is the national religion, neither it nor any other religion is allowed to be taught in the schools.

In the National University there are four faculties—law and social science, medicine, exact physical and natural science and philosophy and letters. In 1901 there were 3562 students in the University.

In reference to religion, everywhere in Argentine, under the Constitution, all may worship God freely, according to the dictates of their own conscience. While the Government itself, like the Governments of Great Britain, Germany, Switzerland, etc., recognizes an established church and assists in its maintenance, it also often assists in benevolent and educational work undertaken by other denominations.

Argentine is made up of many nationalities. According to the census of 1895, there were in the country about 3,000,000 Argentines (all children born there of foreign parents are Argentines) and about 500,000 Italians—by far the largest number of immigrants—and they are far better than the immigrants of the same nationality that come to the United States. Some of the best and

most intelligent people in all kinds of business and industries, especially in agriculture, are Italians. Next come the Spaniards, about 200,000; next the French, somewhat less than 100,000; next the English, 22,000; next the Swiss, 15,000, and lastly the North Americans, as we are called, 1400. These figures refer to the year 1895; the number of foreigners in the country December 31, 1899, was 1,199,808, an increase of 20 per cent. on the returns of the year 1895.

Immigrants in 44 years			1,935,077
Italians	"	"	1,198,550
Spaniards	"	"	361,079
French	"	"	162,636
British	"	"	34,031
Austrians	"	"	31,698
Germans	"	"	27,834
Swiss	"	"	24,873
Belgians	"	"	19,082

In addition to telegraph lines, there are four cable companies working with Europe and the United States, keeping up a close connection with all parts of the world. The service is very good and prompt; its time of transmission between Buenos Aires and London, "via Galveston" and Western Union lines and cables, is about 60 minutes, and with New York 30 minutes. When we consider the distance and the route, we are astonished at the working of this line, which crosses over the Andes 12,000 feet above the sea level, tunnels under the snow and avalanches and reaches the Pacific Ocean, only to take successive leaps by loops along the coast to Tehuantepec, in Mexico; over the Isthmus, across and under the waters of the Gulf of Mexico, to Galveston, speeding then its swift flight over the poles of the Western Union to New York City; and then, without stopping to rest, plunges into the depths of the Atlantic Ocean and talks to the receiver in London in 60 minutes after it left the operator's fingers in Buenos Aires. By a wonderful invention of recent years, this message has passed from ocean to land many times and back to ocean without stopping, through a "human relay"—a machine worked by a human.

It is an interesting fact that the difference in level between the highest point on land of the lines of the Central and South American Telegraph Company and the lowest point of its cables in the Pacific Ocean is about 31,000 feet—6 miles.

This company has three underground cables which cross the Andes and work uninterruptedly, notwithstanding that they are covered with snow, in some places at great depth, for about eight months of the year.

After stating these general characteristics of the country and of the capital city, I must give you a brief *résumé* of the ocean commerce, which has done so much for the country, and, situated as it is at the antipodes of the world, so necessary. First, a few dry facts, and then the description of commercial facilities.

In 1899 the value in gold of goods imported was about $117,000,000; exported, $185,000,000. Of these, $44,000,000 imports came from Great Britain and $15,000,000 from the United States; Italy comes next, with $14,000,000, and Germany next, with $13,000,000; then France, with $11,000,000, and Belgium, with $9,000,000. But exports show a different distribution, for France took $41,000,000; Germany, $29,000,000; Belgium, $24,000,000; Great Britain, $22,000,000; the United States, $8,000,000, and Italy, $5,000,000. Of the foreign trade, Buenos Aires had 87.2 per cent. of the imports; Rosario, 8.8; La Pata, 1.2, and Bahia Blanca, 0.8. Of the exports, Buenos Aires had 55.5 per cent.; Rosario, 18.4; La Plata, 2.3, and Bahia Blanca, 7. These ports are mentioned because some information about them is needed to explain the commercial situation. Of all the goods reaching the River Plate countries, 80 per cent. goes to Argentine.

In 1885 the National Government began the construction of very large docks at Buenos Aires; hitherto all the business had been done from the anchorage, about 12 miles from the city, the intervening space being a great mud bar, the water from a depth of 25 feet gradually shoaling to the shore line at the city. This was so flat that it was necessary often to transfer the passengers and goods from the lighters, with which they had come thus far from the vessels, to small boats and to great wheel-carts that went out a long distance in the water to meet the lighters.

The new docks are very extensive, and lie along the immediate front of the city and connected with it; they were designed by the well-known English firm of engineers, Hawkshaw & Hayter, and carried out under the supervision of Mr. James Dobson, the resident engineer, and a member of the firm. The concessionaire was an Argentine citizen, Mr. Madero; the contractors were the experienced English firm of Walker & Co., who built the Manchester Ship Canal. These men all deserve the highest credit for carrying through, under the financial difficulties of the period above mentioned, a great public work, costing $38,000,000 (gold).

In order to reach the docks from the sea, a channel had to be excavated in the mud foreshore from the anchorage. This channel (the north one) is, at low tide, 21 feet deep and 330 feet wide, and about $5\frac{1}{2}$ miles long from its intersection with a channel which

The Riachuelo in 1901.

Entrance of North Basin.

View of Docks from the North Basin.

One of the Four Docks.

already existed by previous dredging from the other end of the port, at the mouth of a small, sluggish stream called the Riachuelo, in which channel there generally is about 19 feet of water at low tide. The tide of 2 or 3 feet, depending largely upon the direction and force of the wind and very uncertain, permits vessels drawing about 23½ feet to enter the port by the north channel. The new port was connected with the older port, and now both channels are being used, and the depths in them are about as I have stated.

The Government has recently extended the north channel straight out to the anchorage. The depth of water in the northern entrance basin of the port is 21 feet, but in the four great docks 23 feet, with tidal gates, so that the vessels at low tide may be afloat.

The works are built in the most substantial manner—masonry walls founded on what is called "tosca" (loess), the hard substratum that is found in this part of the country. The four docks, or basins, are from 620 to 750 yards long, and are all 170 yards wide, connected by passageways 22 to 27 yards wide, over which passes by means of hydraulic turning bridges, the foot, vehicular and rail traffic. A sea wall in front protects the entire port. On the city side are three- and four-story brick warehouses, twenty-four in all, with a total frontage of 1½ miles. Sheds, cattle yards, railroad tracks, hydraulic cranes and capstans and other important appurtenances give the port modern facilities for handling cargo.

When the docks were opened at the southern end, in 1899, the registered tonnage of vessels arriving and departing at the port of Buenos Aires was 3,800,000; in 1901, 8,661,299, more than 100 per cent. increase. There are only twelve ports in the world of greater tonnage, and none of them shows such phenomenal growth.

In 1880, about the time that the works were proposed, the tonnage was 644,570, and the plans were made for 2,000,000 tons only.

The extraordinary growth of the commerce has made it necessary to make an enlargement of the facilities, and this was one of the works intrusted to me during the last year of my stay in Argentine. I am able to show you the general plan of the actual port, with the proposed enlargement, which will have free access from the sea and a depth of 26 feet.

The plan also provides facilities for "inflammables"—coal, petroleum, gasoline, naphtha and some explosives.

The work of enlargement of the port is divided into sections, so that it can be carried out section by section, as the increase of

commerce will require. The general plan also includes the protection and deepening of the entrance channels.

One of the principal ports of the country is Rosario. Ocean navigation reaches it, and, for that matter, reaches Colastiné, the port of the city of Santa Fé, the capital of the Province. The registered tonnage of the port of Rosario in 1899 was 3,000,000, of which more than 2,000,000 were over-sea vessels, about 700 per annum. The merchandise entered and cleared was about 1,650,000 tons; 67 per cent. of the exportation was wheat. In the busy months there are often over thirty vessels seen at one time along the wharves and the barranca, where the wheat is loaded in bags, sliding down from the high cliff 60 feet above the vessel, in what are called "canaletas." The imports amount to about $10,000,000 (gold), and the exports to $30,000,000.

The National Government is making a great port of Rosario, endowed with all modern facilities for handling cargo. It sent out to Europe and the United States a full report with all necessary data, submitting the project to capitalists and contractors, with the request for propositions to build and operate the port. It will cost from $10,000,000 to $12,000,000 (gold).

The contract, after an examination of and report upon the projects presented by a Board of which I had the honor to be President, has been let to the well-known and experienced firm of contractors, Messrs. Hersent, of Paris, associated with Schneider & Co., of Creusot, the Krupp of France. The works of construction were inaugurated by the President of the Republic on October 26, 1902.

The plans of the work have been based on the data above mentioned.

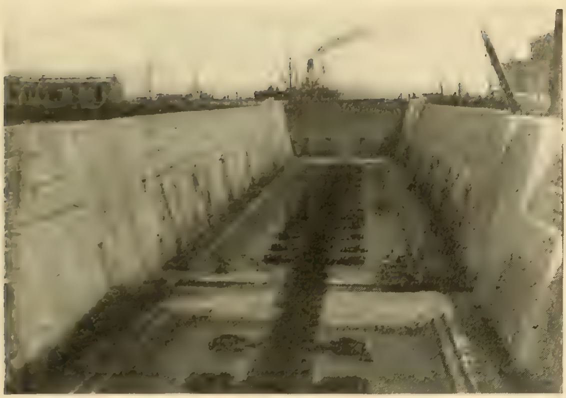
Some important problems had to be solved in connection with the improvement of so great a river as the Paraná, the bed of which is subject to such important changes, and also its islands and banks.

The front line of the proposed wharves is over 2½ miles long. The masonry piers must go down into the tertiary sand below the scour of the river, and their foundations will be from 60 to 80 feet below the low-water level.

The importance of this work, furnishing a modern seaport to the second city of the country, can scarcely be overestimated. In my report on the project, made in September, 1900, I used the following words, which two years of subsequent study have corroborated:

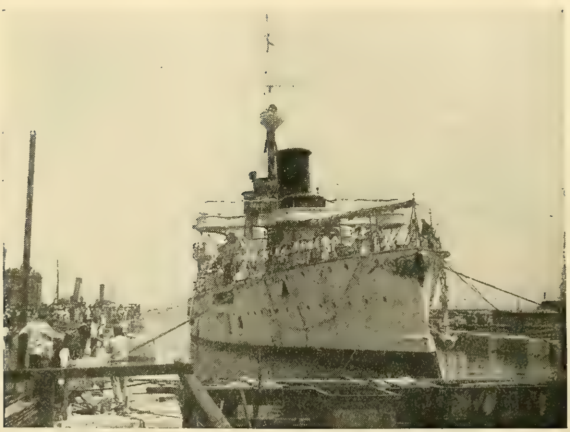
"It is safe to say that the establishment of a first-class port

Port of Buenos Aires and Plan of Enlargement.



The Dry Dock.

President Roca Inaugurating the Dock.



The "San Martin" in the Dock.

at Rosario, with suitable channels of access, will revolutionize completely the commerce and industry of this Republic."

La Plata port and city were built by the Provincial Government, when, in about 1880, the National Government came to Buenos Aires to occupy it as the capital of the nation. It is an excellent port; it is built on the shore of the Rio de la Plata, about 35 miles from Buenos Aires, and cost about $14,000,000 (gold). The opening of the national port at Buenos Aires has driven most of the commerce from La Plata, but it is capable of being made, with a comparatively small sum of money, deep enough, in its entrance channel (5 miles long) and in its port areas, to accommodate vessels of 26 feet draught at low tide; it now has 21 feet.

The remaining port of importance and rapidly growing is outside of the River Plate, in the south, Bahia Blanca; it is the principal shipping port of agricultural products by the Great Southern Railway, the largest system in the Republic. This port is in an estuary of the ocean, and is a protected harbor; in fact, the terminal of the railway is about 35 miles from the open ocean. The railway is building a steel pier, 1640 feet long, with spacious warehouses and 19 miles of siding; and there will be, when all the works are completed, over half a mile of wharf frontage, supplied with electric cranes.

The National Government is building in this estuary at Puerto Militar, or Puerto Belgrano, a system of dry docks and basins on a large scale. The first dry dock, one of the best and largest in the world, is completed and now in use. It was designed and built under the immediate supervision of the well-known Italian engineer, Chevalier Luigi Luiggi, who had charge of similar work at Genoa.

This dock, built of first-class materials and upon the most modern methods, can take the largest naval or merchant ships of the world, as it has a useful length of 713 feet and an entrance width of 85 feet and a depth over the sill of 32½ feet at mean high tide, 22 feet at low tide. It has intermediate gates, so that two or three small vessels can be docked at the same time or separately.

I cannot here go into details of construction, which were fully given in a paper on the subject submitted by Mr. Luiggi to the Ninth International Navigation Congress at Düsseldorf, July, 1902. He has very kindly given me over thirty lantern slides, of which I can show you a few, to give you a general idea of the dock. The plans, photographs and, possibly, a relief model of the dock will be exhibited at the World's Fair in St. Louis, in 1904.

In October last the United States battleship "Iowa," the flag-

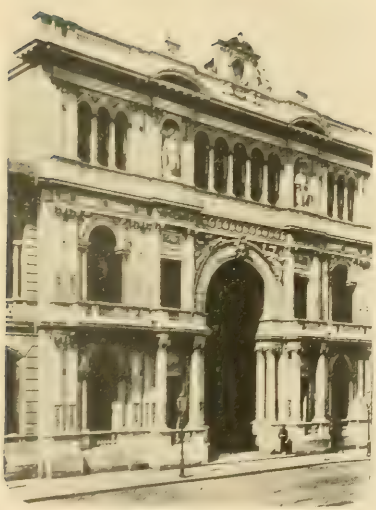
ship of the South Atlantic squadron, was docked at Puerto Militar.

You will be interested to know that at Buenos Aires there is a large business with New York by means of five steamship lines, and, through New York, with other cities, from which are shipped a large amount of agricultural machinery of all classes, from cultivators and plows to great steam threshing machines of the "J. I. Case Company," of Racine, Wis. From all manufacturing districts the trade of our country is increasing. You see our machinery everywhere, and it is everywhere considered equal to any—Baldwin locomotives, Jackson & Sharp cars and Harlan & Hollingsworth's. The American freight car of 25 and 30 tons is replacing the old Belgian, French and English 7- and 10-ton cars. If the American cars are not all made in the United States, they are copied from ours. The most approved bridges are from the United States. I have been over several and examined one on the Transandine Railway, built by the Phœnix Bridge Company, of Philadelphia, excellent bridges and giving entire satisfaction. The Boston Bridge Company sent out some very good bridges. The horse cars by John Stephenson & Co., of New York; electric cars by the J. G. Brill Company and the Westinghouse Company are doing well there. Large quantities of Southern and Oregon pine are imported. From the United States comes all the kerosene used in the country. I might go on enumerating many other United States products. I can well say that the prospects of American trade with Argentine are exceedingly good.

The Argentine Government is determined to improve the great rivers of the country by methods which have been found to be best in other countries under similar conditions. The results of our experience upon the Mississippi are being closely watched, studied and applied. The reports of the Mississippi River Commission are of great value to that country. I may further say that the engineers and the methods pursued by them are equal to those of any country. Every Government engineer, to take a prominent position, must have a diploma from the Engineering Department of the National University. The graduates of this excellent school are as well equipped for their work as those from any school in the world; this I know by experience, for four of them (young men) have been associated with me as my immediate assistants, and, in my position as Consulting Engineer of the Government, I have been brought into close relations with many other engineers, and I have the highest opinion of their ability.

The Government Building—Casa Gobierno—sometimes called

U. S. Battleship "Iowa" Entering the Dock.



Entrance of the Government House.

The "Prensa" Building.

The Sarmiento School.

the "Casa Rosada," from its light rose color, and in which was my office, is one of the most prominent buildings in Buenos Aires.

It stands in a prominent and central position, facing the Avenida de Mayo, and looking out on the other side over the port and the River Plate.

One of the finest structures in Buenos Aires is the "Prensa" Building, devoted entirely to that morning paper. I know of no newspaper offices in the world that can compare with this in elegance and convenience in all its interior appointments.

The leading newspapers of Buenos Aires are equal to any, both in editorial ability and in telegraphic news from all parts of the world.

The Sarmiento School gives me an opportunity to call your attention to one of the most learned and best of Presidents, who, when he was Minister at Washington, became so interested in our educational methods that he engaged a large number of our young lady teachers to go to Argentine as normal school teachers. Many of them are there yet, after nearly twenty years' service—a service that has reflected honor upon themselves and their country.

You may properly ask me why I have brought before you the subject of Argentine. I can easily reply—first, because in two years of close relations with the country, and especially with the Government officials, I formed a very favorable idea of the character of the people and of the possibilities of business and profitable enterprise for our own people there; and, second, because the high officials of the Government and leading men of the country desire to have the "Norte Americanos," as we are called, come to Argentine with their business energy, integrity and ability, and their capital as well, to help build up and move forward to its high destiny that great country of South America, so like our own in its climate, soil, rivers, coast line and other general features.

If I have succeeded in interesting you in Argentine, and in giving you more knowledge of it than you had before, I shall be satisfied with my efforts and feel that I have done a service to that country and to my own.

RICE IN TEXAS AND LOUISIANA.

By Francis M. Henry, Associate Member of the American Society of Civil Engineers.

[Read before the Engineers' Club of Minneapolis, February 27, 1904.*]

The cultivation and use of rice as a food antedates authentic history.

"It is mentioned in the Talmud, though neither in the Old nor New Testament. It was certainly known to the Romans; was set forth in the tragedies of Sophocles, B.C. 495. It was described by the Greek philosopher Theophrastus, B.C. 300. Legend places its introduction into China, B.C. 2822. It had undoubtedly spread throughout the tropics long before the commencement of the Christian era."

One-half the population of the earth use rice as their principal food. It has been selected as the staple wherever climatic conditions permitted its cultivation. As certainty of supply is of first importance among most dense populations, the dependence on rice, in such closely settled lands as Japan, China and India, is easily explained. The Chinese Empire, with 400,000,000; the British possessions in Asia, with 300,000,000; Japan, with 40,000,000, and other islands and nations aggregating about 100,000,000—of these 840,000,000 rice constitutes the principal food supply.

"Rice is raised in China, Japan, India, Ceylon, Siam, French Indo-China, the Straits Settlements, the Philippine Islands, Persia, Asia Minor, Africa and the islands of the Indian Ocean, Egypt, Senegal, French Sudan, Algeria, Tunis, Madagascar, Honduras, the Hawaiian Islands, Brazil, United States of Colombia, Peru, Australasia, the Pacific Islands, Australia, France, Italy, Spain, Mexico and the United States."

In China, the cultivation of rice extends all over the eastern and southern portions of the Empire. Lowland and upland rice are both cultivated, but, in spite of the great area cultivated, the product often falls below the home demand, and it is imported from Siam and the Malay Islands. The exportation has, upon occasions, been forbidden for several centuries.

The rice lands in China are generally in the hands of large proprietors, and by them leased to farmers, or land gardeners, for each man usually cultivates a lot of not more than a half to two-thirds of an acre, and frequently less. They pay a rent which is equivalent to from $7.00 to $10.00 per year, the landowner taking

*Manuscript received March 18, 1904.—Secretary, Ass'n of Eng. Socs.

about one-fifth of the crop, though frequently a full half falls to his share.

The most primitive implements, and those that have been in use for a thousand years, are to-day found in China. Chinese conservatism distrusts any innovation in the way of modern instruments or machinery. The hoe and spade and sometimes the wooden plow, shod with iron, are the only implements used. Fertilizers are used and held in great faith. As the country abounds in rivers and small streams, canals are taken for irrigation, though regularly organized systems, such as are in Japan, do not exist. In some localities, away from a natural water supply, the rice growers unite and convey water to the fields, raised by water wheels and driven through bamboo pipes. Hillsides and slopes are terraced that the fields may be level, and are so arranged that after a sufficient depth of water is supplied to one terrace, it will flow upon the next field, and from this to the third, and so on, to the lowest level.

"The rice is first soaked in water saturated with some fertilizer known to them, and this forwards the growth so much that young plants, after being deposited in the earth, appear above the ground in two days. As soon as they have reached the height of 6 or 7 inches they are pulled up, the tops cut off, the roots carefully washed and the whole planted out in rows about 1 foot apart. While growing, it is sprinkled with lime and water, to destroy insects and assist in enriching the soil. The first crop, for the Chinese in some localities obtain two in the course of a year, is harvested in May or June; the second, in October or November. The sickle is used in reaping, and resembles the European instrument, but, unlike the latter, it is notched like the teeth of a saw. The straw and stubble are burned and left upon the spot to enrich the soil. The Chinese have long been accustomed to improve their rice by the selection of seed, and this is enjoined by imperial edicts." Harvesting and threshing is done after very ancient methods. The rice is cut with a sickle and threshed by treading with oxen or by the flail. Another way of threshing is by beating the heads of the grain against the edges of a box into which the paddy falls. Pouring the grain from baskets in the wind, or fanning with large paper fans in the absence of a breeze, constitutes their winnowing process. It is hulled by crude mortars and pestles. The best fields will average, it is said, about 4000 pounds per acre, or 2000 pounds at each crop, which would be equivalent to about twelve sacks per acre per crop.

It is said rice land in China sometimes is sold for a price equivalent to $300.00 or $400.00 an acre.

In Japan the plow is rarely used; the soil is dug with a mattock,

and an implement similar to a harrow is frequently employed to pulverize it. Sometimes this is drawn by an ox or horse, but more frequently by manual labor. As in China, they pay particular attention to fertilizers, and sow the rice broadcast, and afterward it is transplanted in rows. An essential difference, however, is that in Japan mountain streams have been directed to supply large and substantially built irrigation works, and great districts are often traversed by canals, winding around the mountains, and thus equalizing the water supply for the crops throughout the year.

The average yield of rice in Japan is equivalent to sixteen sacks per acre, and the selling price about $2.40 per sack, and the rice, as to quality, second to none. The progressive Japanese, of late, have been continually sending agents to the United States with a view of bettering their systems of rice culture, and although the Government tax on rice is very high, the edict forbidding its exportation has been repealed, and we may expect great advances in rice growing in that country.

In India the number of acres cultivated in rice reaches something over *sixty millions* in an average year. It forms the principal food of that vast population, estimated to be 20 per cent. of the people of the world. It is the crop of greatest importance. All sections of the country produce it; all varieties of soil yield it, and under widely differing conditions of climate, altitude and water supply. It is estimated, in India, that 1400 varieties of rice are now to be found.

In the space of this brief paper, it will be futile to attempt the enumeration of many of the different varieties or to describe the various modes of cultivating rice in India. "Thus in Bengal much dependence is placed upon the rainfall for one variety which is grown on the light, sandy soils not using irrigation, while another grows upon the low alluvial tracts and is irrigated; in a different section the rice grown is of the red variety of lowland rice, where dependence for irrigation is placed upon the influx of sea water. The fields being diked, the sea water is drained out at low tide, and a herd of buffaloes are hastily driven over every portion of the field and the seed placed in the tracks made, the members of each family being then obliged to stand guard on the dikes built to preserve the precious seeds from air fowl till the growth has started."

In still another section, "The water is drawn off the land, and the head of the house, with his entire family, joins in a frolic, until the whole field is reduced to the consistency of liquid mud, into which the seed will sink of its own weight upon being scattered."

"While in Nepál, the Joomla rice, an upland variety, 'flour-

ishes without inconvenience amid the snows and frosts of the Himalayas, at elevations of from 6000 to 7000 feeet (and it is interesting to note that this latter has been successfully raised upon the banks of the Thames in England.)"

It is safe to say that the primitive methods of rice raising existing in China and Japan have not been improved upon by the rice growers of India.

The Philippine Islanders cultivate rice after quite as primitive a manner as the above countries. The home production is inadequate and large quantities are annually imported. The Hawaiian Islands, Porto Rico and Cuba all import rice.

Passing a further description of the methods employed in the cultivation in the remaining various countries before named, as they are all more or less similarly primitive, and considering at once the history of this cereal in the United States, we find that "early in the eighteenth century an alleged East Indian man was blown ashore on the stormy coast of Carolina, and it happened that part of the cargo was saved, and one small package fell to the lot of a French Huguenot refugee, who had fled from the turmoils of France and settled on the Atlantic shores of our southern colony. This colonist recognized in the little brown seeds, that his fellows mistook for barley, the *great East Indian staple—rice*. He planted it in the low, marshy river bottom and, in time, a crop was harvested."

From this small beginning the rice industry of South Carolina grew. For 190 years after the introduction of rice in the United States, South Carolina and Georgia produced practically all that was raised.

The lands used for rice culture in these States were low and marshy, and bordered on the rivers emptying into the sea. The irrigation of the land was obtained by diking the fields adjacent to the streams and allowing the same to be flooded by the back water at high tide and the water taken off, or the fields drained, by opening the gates, with the ebbing tide. "The sediment carried in the Savannah, Combahee, Ashepoo, Edisto, Cooper, Santee, Sampit, Pedee, Black and Cape Fear Rivers greatly enriched the soils they flooded, while many times a heavy freshet upon one of these, being met by a storm from the sea, has wrought great havoc."

In these States rice was seldom grown within 15 miles of the sea, or more than 30 miles from it. This 15-mile belt was fixed, on the sea side, by the presence of salt water in the river, and on the land side by the point at which there was not sufficient difference between high and low tide. A 2-foot tide has been taken as the minimum for drainage and irrigation purposes. Great canals con-

nected remote plantations with the tide streams. The methods of irrigation were crude, and to-day the systems of the colonial planters are still in use. The rice is drilled in rows, 14 inches apart, and sometimes immediately flooded to protect the grain from birds, the water drawn off and not put on till the plant has reached 5 or 6 inches, then the "stretch flow" is put on for several days, after which follows the "dry growth," which lasts some forty-five days, and, in well-drained fields, the crop is cultivated during this period by horse and hand hoes. Rice cannot be grown successfully in these old States without cultivation. The soil is such that water cannot take the place of hoeing. Also, the conditions are not suitable for harvesting machinery. The sickle is used, and colored men and women cut, tie and cock the grain.

From 1847 to 1861 the average yield of the United States was 116,000,000 pounds of cleaned rice. The period of the Civil War diminished this to an average of but 2,000,000 pounds. "The industry had been remanded to its infancy. The long abandoned fields had grown up in a tangle of brush, vines and trees; the once disciplined and supremely efficient labor of the country had turned into a mob." Many failed, and few who undertook to renew their old-time calling succeeded, because of the changed conditions.

After 1861, however, *Louisiana* began to come into importance with her rice crop; so that in twenty years, or in 1881, she produced as much as all the rest of the United States combined, and in 1899, out of 137,000,000 pounds of cleaned rice, Louisiana produced 108,000,000 pounds.

It is interesting to know that during this same year, 1899, the United States imported 153,837,000 pounds of cleaned rice, or 16,837,000 pounds more than she produced. Let us look for the reason of Louisiana's wonderful growth in rice growing.

"Longfellow and George W. Cable have made the world acquainted with the French settlers of Nova Scotia who, driven from their homes, have borne exile in Louisiana for the past 150 years. These farmers depended chiefly upon their herds of cattle feeding in the upland prairies, though simple farming was carried on, and rice, among other products, was raised. There were few wants the country did not plentifully supply."

These Acadians, in raising rice, depended solely upon the rainfall to flood their crops. Irrigation was unknown to them. "From a commercial point of view, their rice crop was insignificant and their methods were too primitive to admit of progress." Hence, for 100 years preceding the Civil War, the rice industry in Louisiana remained stationary. After this date, however, men of more

ambition went to Louisiana and experiments soon began to be made. They stored water and raised levees about their fields. Presently they discovered that the great prairies adjoining and between the "bottom" lands could grow better rice than the bottoms themselves, when there was plenty of rain. The problem then was to raise water to flood these prairies. Small steam pumps were first employed to raise the water from the bayous, but it was not till 1896 that the first real success was attained by the use of a centrifugal steam pump, 2 miles northwest of the town of Crowley, in Acadia Parish, La. Its operation during the summer of that year marked a new era in rice cultivation.

The result of successful irrigation on prairie lands caused a rapid rise in the value of such lands and brought them immediately in demand. As this success became known and fully substantiated, the area for rice culture extended, until a vast territory was included.

Following closely upon the heels of prairie irrigation came the discovery that rice could be harvested by the same machinery that harvests wheat, that the same drills could plant it in the ground and that the soil of these prairies could be kept free from weeds by water, and hence no cultivation was necessary after the crop was seeded.

Another most important discovery came about this time, in the ascertaining of the existence of an immense underground reservoir or stream underlying the whole country, in what is now known as the Louisiana and Texas rice belt. This subterranean lake or river, for it seems to flow slowly toward the Gulf, is found in a great sand and gravel water-bearing stratum lying from 12 to 20 feet below the surface, and it has been ascertained to be practically inexhaustible.

These last discoveries immediately made it possible for great profits to be obtained in rice cultivation; it plainly showed "that the immense coastal plains had found their redemption, that this cereal was to rescue them from the reign of the steer" and turn the country into a most thrifty agricultural section.

To-day, the rice belt, or the district where rice can be raised after this fashion, covers in extent about 250 miles in length by 40 miles in width. It extends from about the 92d degree of longitude in Louisiana on the east to the 98th degree in Texas on the west. On the south it is from 20 to 35 miles from the Gulf, and on the north from 60 to 75 miles.

The country near the Gulf is, for the most part, a low swamp, occasionally flooded by the sea when strong offshore winds prevail;

but back of the swamp district lie the great prairies sloping toward the Gulf, falling about 2 feet to the mile and interspersed with stretches of timber on the "bottoms" along the streams. To the eye the country is most beautiful, for a prairie district, and it differs from our northwest prairies in being a luxuriant green, because of the sufficient rainfall, and also in always having as a background a bank of tall timber outlined against the sky.

The soils in Louisiana are mostly lighter than in Texas, being for the most part of a sandy loam, underlaid with a clay subsoil. In the rice district in Texas the "black waxy" and "hog-wallow" lands are the most sought after, though the sandy loams underlaid with clay are also used. The "waxy" or "hog-wallow" lands are impervious to water themselves, besides having the clay subsoil, and these latter yield enormous crops and require no fertilizers. The "bottoms" lying between the prairie stretches and along the streams have been in cultivation for many years, and cotton, corn and cane are the great staples raised thereon.

To-day the negro labor in this district is confined to the bottom-land products, viz., cane, cotton and corn, and the white man alone is found on the prairie with the rice, the reason being that the former is as yet unfit, as a whole, for the running of machinery, etc., or for any form of labor differing from that to which he has for generations been accustomed.

The methods of raising and distributing water for irrigation purposes in use to-day in these two States are as follows: Irrigation companies controlling and owning large bodies of land, running all the way from 500 to 10,000 acres, raise, by huge centrifugal pumps which are driven directly by powerful steam engines, vast quantities of water from the bayous and rivers, and discharge the same into the great canals, which, in turn, distribute the water by laterals, sometimes alone by gravity and sometimes through the aid of a second or third lift (as the different pumping stations are called). These great centrifugal pumps, some of them discharging a stream 6 or 8 feet in diameter, have the enormous capacities of from 50,000 to 75,000 gallons per minute. Frequently these companies have three or four of such pumps lifting water from a river or bayou into the irrigating canal. Such companies make contracts with rice farmers, whereby they agree to furnish land and water for a consideration of two-fifths of the harvested crop, the farmer simply furnishing the seed and necessary labor to grow and harvest the same.

The other system of rice growing is that of the independent

landowner, who irrigates his land by pumping water from his own well. He plows when it suits him best, disks, seeds, irrigates, drains the land and harvests his crop when, in his own judgment, it is best for him to do so, and has nobody but himself to blame for the results.

He can obtain sufficient water to irrigate 100 acres from an 8-inch well, 100 feet deep, and by attaching a centrifugal pump, driven by either a gasoline or steam engine, he is insured more constant success than in any other agricultural pursuit.

This last system is fast becoming very popular, and deservedly so, as its advantages can be easily appreciated. American farmers like to own their own land. This is part of their nature. The artesian water is free from all impurities, seeds, etc., carried in the river water. The farmer can get the water the very day and hour that his crop may need it, and, also, it can be drained off at his will. He is embarrassed by no long delays and broken promises for water on the part of some big irrigating company. It is his own fault if he does not raise a crop. The greatest successes have been attained by individuals using the well system.

Let us look into the financial end of one of these farmers using the well system.

THE FIRST YEAR HE PAYS

For 100 acres at $40.00	$4,000.00
" building levees (at $1.50 per acre)	150.00
" well and pumping plant, complete	1,500.00
" house, barn, etc.	1,000.00
" breaking	250.00
" disking	150.00
" seeding and seed	250.00
" irrigating	300.00
" harvesting	240.00
" threshing and sacks	494.00
Total first year's expense is	$8,334.00

Taking an average yield of fifteen sacks per acre and the average price of $3.00 per sack of rough rice of 162 pounds, we have as the gross receipts of this first year $4500.00.

A man to start a 100-acre rice farm should have capital at his command sufficient to carry him safely through the first year. Should one be in such shape and be otherwise fitted, the results of the second year would be as follows:

Plowing	$100.00
Disking	100.00
Repairing levees	25.00
Planting	100.00
Seed	150.00
Harvesting	240.00
Threshing	494.00
Irrigating	300.00
Interest on investment at 5 per cent	332.50
	$1,841.50
1500 sacks at $3.00	4,500.00
Net profits, end of second year	$2,658.50

Compare the above with the renter from an irrigation company.

SECOND YEAR.

Plowing	$100.00
Disking	100.00
Repairing levees	25.00
Planting	100.00
Seed	150.00
Harvesting	240.00
Threshing	494.00
	$1,209.00
1500 sacks, total crop	
Less ⅖ for rent, 600 "	
900 " at $3.00	2,700.00
Net profit	$1,491.00

I have in mind a man named J. W. Leach, in whose house I have been and whose farm I have inspected, and who the first year, on 160 acres, with two wells, raised 2268 sacks of "Honduras," that sold for $3.20 per sack of 162 pounds each. This man is a native of Illinois, and the above was his first crop. He told me his gross receipts, straw and all, this year were $8375.40. His entire outlay, land and all, was less than $10,000.00.

If the work of irrigating is excepted, the process of raising rice is practically the same as wheat or oats in the North.

The land is plowed with gang plows, in the fall or spring, sometimes both, then disked and harrowed thoroughly. Planting is sometimes done with a broadcast machine, coupled to a farm wagon, or, more often and better, it is drilled in rows 7 or 8 inches apart. The planting season extends from April 1st to June 15th, or sometimes later.

Dependence is placed upon the rainfall altogether to start or sprout the seed and promote the growth of the plant for a period varying between one and two months. Flooding generally begins when the plant has reached a height varying between 6 and 10 inches, and from this time till the grain is in the milk and well formed, a space of about seventy days, the fields are kept flooded.

A couple of weeks before harvest, the levees are cut and the fields drained, and the grain rapidly hardens and matures, so that, by the time the field is ready to cut, the ground is dry enough to permit the heavy threshing machines to be used. These are sent into the fields and the rice is cut and bound and put into cocks, where it is left for a period to thoroughly mature.

The manner of threshing is precisely the same as in the case with wheat, excepting that rice, upon being threshed, has still a hull on it, and also, that instead of being handled in bulk, as in wheat, it is *always* handled in sacks. Upon threshing the rice in the fields, "rice buyers" from various different rice-mill companies make the farmers cash offers. Last season's prices ranged from $2.50 to $3.50 per sack of 162 pounds, depending upon the quality of the rice. Unlike the wheat business, there is no regular grading of the rice before it is hulled. Most of the rice raised in this section is "Honduras," although "Japan" seed has been planted with great success. The degree of whiteness and weight determines the value of the rice.

The great inconvenience and expense to the farmer in sacking all his rice, also the extra work and bother in transferring the same at the mill, occurred to me to be a most useless piece of business, but various reasons were offered why rice could not be handled in bulk by elevators, the sum and total of which were that it had never been done, that *"sacks had always been used."*

The writer, while in that country, has often criticised the old sack system, and has advocated the building of elevators, and it is with satisfaction that it has been noted in the *Houston Post* that this very thing is about to be done, *i. e.,* that a great chain of elevators for rice is to be constructed. This last step will save at least 20 cents a sack to the farmer.

As already stated in this paper, the total yield in the United States in 1899 was 137,000,000 pounds; in 1900 it grew to 219,278,-000 pounds. For 1901 it was 253,139,000 pounds, and 1902 advanced the figure to 390,000,000 pounds, an increase over the previous year of as much as the total crop of 1899.

The acreage devoted to rice growing for 1902 is placed at 400,000 acres, and the estimated available acreage as yet untouched

may bring the total to 4,000,000, capable of yielding some 40,000,000 sacks of 162 pounds each, or 6,480,000,000 pounds, or a crop sufficient to give to every man, woman and child in the United States 80 pounds per year.

It is interesting to note in this connection that Japan raises about $3\frac{1}{2}$ times this amount; British India, $7\frac{1}{2}$, and China, 17.

A fair conclusion would seem to be that America will soon find in rice an extremely cheap and wholesome food, and as these vast districts are devoted to its culture, the food which feeds one-half the world will become most important to us.

THEATER CONSTRUCTION WHICH INSURES PUBLIC SAFETY.

By E. O. Fallis, Member of the Toledo Society of Engineers.

[Read before the Society, March 18, 1904.*]

Why is it that this great government of ours is so careful in the protection of the rights of individual citizens, when interfered with by those of any other government, even going so far as to send men-of-war to distant waters to demand reparation for wrongs inflicted upon an individual, an obscure citizen (and that citizen sometimes an alien), while at home, the rights of one may be trespassed upon by another, or one may infringe upon the right of many in the strife and struggle for gain, even to the extent of causing the death and maiming of hundreds, and go unpunished, overlooked and soon forgotten? Why is it?

The first requisite to change this order of things is a demand from the public; and the second—an enforcement of such demand by adequate laws rigidly and continuously applied. Now let us apply this to the subject at hand:

Few, if any, theaters will ever be constructed that will insure public safety without question until the public demands it and then enforces its will. In considering the question, three factors enter into the problem: First, the public patrons; second, the ownership and management; and third, the architect and builder.

Considering the factors independently, and in the order in which they are named, we shall first discuss the public.

A catastrophe to-day shocks, alarms and disturbs the whole public; steps are immediately taken to investigate the cause and to remedy the evil. To-morrow, new subjects attract the attention of the public and, in a short time, all is forgotten. In the course of a month or two matters are much the same as before. The public crowds the various theaters indiscriminately, the cheap, gaudy, flimsy, life-endangering theaters being as well patronized as those of more costly structure, in which an endeavor to protect the public from danger by a largely increased expense in construction has been made, and with fire marshals, building inspectors and city officials sitting complacently in their private boxes in order to insure public confidence.

It is not to be presumed that the general public should be judge of the safety of buildings, of the construction of which it knows

* Manuscript received March 21, 1904.—Secretary, Ass'n of Eng. Socs.

nothing, but it should demand self-protection through its laws and its guardians. As I have already said, until the public makes the demand and then enforces it, safe buildings will not be constructed.

As for the ownership and management, we all know that those who engage in the construction of theaters do so for financial gain, the largest receipts for the smallest investment being, with few exceptions, the sole object.

A theater of combustible and otherwise dangerous construction can be erected for not more than one-half the cost of one that is non-combustible and otherwise safe, both being of the same seating capacity and equally pleasing in design. All other things being equal, the indiscriminating public will patronize (excepting perhaps for a short period after a fatal catastrophe has occurred at some theater) the house of dangerous construction as freely as the other; consequently, the owner of the house of cheap construction will make twice as much percentage upon his investment as the owner of a house of more expensive construction. Why should an investor construct a fireproof and safe building, knowing the conditions and the field of competition against him? You say there is the moral responsibility. Yes, it is true, but among financiers and theatrical managers such is generally considered only after the fires begin to burn.

In the patrons and in the ownership of such theaters we have the two opposing forces; the public, the buyer; and the owner or manager, the seller. Until they adjust their differences, the architect, in this country, has but little call to exercise his ingenuity in devising a safe theater.

The question of devising laws having jurisdiction over private property and enterprise, and having them properly and justly administered, is a vexed one, and the results are questionable.

In many of the cities of Continental Europe, the theaters, opera houses and places of amusement are owned and managed by the municipalities, which not only protect the public from the dangers of poorly constructed houses, but afford it a higher standard of entertainment and amusement. Supposing the time had arrived when the construction of all theaters was upon the same footing—that one owner had no advantage over another, but all were compelled to build equally good structures—then the architect would be at liberty to devise the methods of construction necessary to produce the desired result.

The greatest danger that threatens a gathering, consisting of a number of people, is a panic, caused from fright and conditions that threaten their lives. The problem to be dealt with is to remove

the cause of all apprehension and to inspire an audience with the utmost confidence. To accomplish this, not only every feature that endangers life, but every feature that may cause alarm in the most timid must be removed. Danger from without, as well as from within, must be guarded against. Exits must be numerous, free and unrestricted; nothing arouses a sense of insecurity quicker than a feeling that the way of retreat is menaced or closed. Danger must not only be eliminated, but proof to the public that such has been done must be made by actual demonstrations and tests.

Having placed the problem before you as I view it, a few suggestions upon a method for accomplishing the result desired may be of interest. First, I will consider the danger from without. A theater may be within itself safe, yet it may be so confined within the walls of a contiguous building, or other buildings located so closely, as to endanger and alarm an audience in case of an extraneous fire. This also might be caused by limiting the surrounding spaces to such an extent as to cause congestion of the public ways, especially should these be already filled by an excited throng, as might, under the circumstances, be the case. To obviate these difficulties, I would erect theaters and such buildings within open spaces, such as the centers of public squares, and arrange them in such a manner that no other building would come in contact or even within a distance of 100 feet of them.

In order to discuss such a construction intelligently, it must be done from a practical standpoint, and certain statements which I make must be considered as facts, as follows: First, an isolated theater, constructed of non-flammable or non-combustible material, and in which no combustible material whatever is stored, will not of itself burn; second, the general public, when witnessing a scene depicted upon a stage, is not yet capable of drawing upon its imagination to such an extent as to supply a lack of scenery, as is the case with the theaters of the Chinese and Japanese. This being the case, it has been found impracticable in nearly all theaters to make scenery of anything but inflammable material. This granted, we must meet the practical demand, and the proposition to be considered becomes:

A theater, all parts of which, excepting the stage, are incombustible, and not subject to the heat of combustible materials; a stage, which may be combustible, and subject to highly inflammable materials. With these as the two factors, the problem becomes a question of completely isolating the theater and constructing a stage that may be completely and effectually cut off from the balance of the theater, in such a manner as to prevent the radiation of heat

or the escape of gases. To accomplish this is not a difficult task—not so difficult as many imagine, although it cannot be done without some extra expense.

There are many ways to form such a construction. A stage should, in my opinion, be considered as a huge furnace, constructed with double walls, air spaces and wickets for passage, lined with fire brick, and provided with great stacks directly over, with highly inflammable valves in each; the proscenium opening being considered the door. This should be closed, not by a great sheet, or make-believe "fireproof" curtain, that may be ripped asunder by the force of the great drafts of air, or fail under such pressure to descend to the stage floor, but by fire- and gas-proof movable walls, composed of boiler iron or steel tanks, formed in several rising sections, one sliding past another, as the space may demand. These sections could be formed like great box girders, the top flange of one hooking into a groove filled with sand, on the bottom flange of the next, and so on, the ends being confined in cast-iron grooved ways. Each tank or section should be completely filled with water, and all counterbalanced by attaching chains at several different points in their length; all operated by hydraulic pressure and worked automatically.

Or the same general scheme might be adopted and constructed of steel and porous terra cotta, or of steel imbedded in concrete. The result is: Destroy the stage, if necessary, but save the people. I am confident that a stage can be so constructed that it may be burned out without the knowledge of the audience at the time sitting before it.

A menace from fire from other sources, internal or extraneous, must be guarded against. No carpets, draperies or upholstering whatever (from a sanitary standpoint as well as from the danger of fire) should be permitted. No room or space in or about the building forward of the stage should be used for the storage of anything. No gas of any kind should be permitted within the building or its approaches. A double system of electric wiring should be used to insure against accident, each system being taken from separate dynamos.

No obstructions, permanent or movable, of any kind whatever should be permitted in passageways. Cloakrooms should be constructed on the same principle as suggested for the stage, *i. e.,* with fireproof walls, ceilings and doors, and large flues opening above the roof of the theater, that smoke and other gases might be quickly and completely carried off, in case fire should start within them.

No business whatever, other than for theatrical or similar purposes, should be conducted within or contiguous to the building. The planning of the building, the proper distribution and proportion of exits, the staircases, widths of aisles, spaces between rows of seats, as well as the various and numerous ways of extinguishing fires, I will not take time to mention, more than to suggest that, of course, it would be wise economy to employ upon the stage such fire-preventing and extinguishing appliances as may be approved. In other parts of the building such precautions would not be necessary.

ORIGIN OF THE UNITED STATES LAND SURVEYS.

By W. A. Truesdell, Member of the Civil Engineers' Society of St. Paul.

[Read before the Society, March 14, 1904.*]

There would be a good opportunity in the field of historical research for someone to write a history of the early land surveys and the origin of the system. The author who attempted it would be greatly surprised at the outset, for, in the line of special history, he would find a remarkable scarcity of material, and in official records and reports, where he would naturally look, absolutely nothing. With those who had ever considered the subject he would encounter a wide diversity of opinion, and among the men who at different times had been credited with the method there would appear the names of Jefferson, Thomas Hutchins, Rufus Putnam, Jared Mansfield, Edward Tiffin, William Henry Harrison, and Washington, for it is true that all of these men have had supporters, and evidence has been produced and arguments made to show that each of them originated the present method of United States land surveying.

At first, and for many years, it was supposed that Jared Mansfield devised the plan. This opinion was due to some very erroneous historical statements in the early editions of Davies' "Treatise on Surveying," where it was said that Mansfield alone originated the system, that no general plan had been in use by the Government before the year 1802, and one would infer from the language of the text that the method was invented on short notice and applied to immediate use in the Northwest Territory.

Professor Davies' statements had a baneful effect, because they taught false history. Instead of being an instantaneous production and the work of one man, the method of United States land surveying is the result of development, extending over several years of time, and has been built up the same as other systems of business.

Mansfield's services on the early surveys were invaluable, for it was he who reduced confusion to order and perfected the system. Nevertheless there were men before him who had originated that system, applied it to practice for seventeen years and had opened up a field wherein he might improve, but could not invent.

In the above-mentioned names there are three at least who are entitled to consideration. At the same time we could give credit to one or two others. Thomas Hutchins, Rufus Putnam and Jared

* Manuscript received March 23, 1904.—Secretary, Ass'n of Eng. Socs.

Mansfield, each in turn, conducted the early surveys, and the terms of their services cover a period of 27 years, during which the system was inaugurated, developed and brought to a final completion.

A detailed account of these men while engaged on this public service, their characteristics, acquirements and qualifications for the duties required of them, their management of the work and the manner in which it was executed, the part that each one contributed and how they acquitted themselves would form a very interesting chapter in American history.

What might be called a germ, which afterward grew to maturity, was a plan devised and submitted by Thomas Hutchins 12 years or so before the Revolution. In the famous Indian expedition commanded by Col. Henry Bouquet, Hutchins was a captain in one of the regiments and served as engineer officer. After the return to Philadelphia a report was printed, a part of which consisted of a scheme, submitted by Captain Hutchins to the Colonial Government, for the protection of settlers on the frontier against Indian hostilities. His plan, which was written out in detail and illustrated by a map, was this:

For a colony of 100 families, or 500 people, lay out a tract of land 1 mile square on some stream, and in the center build a stockaded fort. Divide the remaining land around the fort into streets and lots, 100 lots in all, of about 5½ acres each, one lot for each family to build upon. Around the 4 sides lay out 8 more squares, each a mile in size, one of them to be reserved for woodland and the others to be divided into plantations or farms for the colonists, a farm for each family. In this plan Captain Hutchins used the word square. Repeat the operation and lay out another colony immediately adjoining or some miles distant, according to the necessity or circumstances. In this manner cover the whole frontier line with a row of forts and colonies.

This was the first suggestion ever made for dividing land into regular tracts 1 mile in size, and it has been considered by some to be the origin of the method long after adopted. What result this plan had on subsequent legislation, when the first land law was enacted, can never be known. It must have been widely read at the time, and in some manner might have been instrumental in the formation of the system of surveying our public domain.

The next step, or perhaps what might be called a first step in the origin of the method was this: In 1783, after the close of the war, but before the army was disbanded, a mass meeting of nearly 300 officers was held and a petition to Congress drawn up. The prime mover was Rufus Putnam, and probably he wrote the petition

which asked Congress to grant that all the lands they were to receive under the act of 1776 should be in one body and located between the Ohio River and Lake Erie. Putnam was charged with the duty of presenting the petition to Congress, which he did, through his friend Washington, to whom he wrote a long letter, in which he gave his reasons why the petition should be granted. In this letter General Putnam used the following language:

"The petitioners hope that no grant will be made, except by *townships 6 miles square,* or 6 by 12, or 6 by 18, to be divided by the proprietors to *6 miles square,* that being the standard on which they wish all calculations to be made."

Mark the word township. This is considered by many people who know the facts to be the origin of the method which was afterward put in practice. It was the first suggestion ever made, or the first plan ever proposed, of which there is any record, for dividing the lands of the Northwest Territory according to a method which two years later was enacted into a law. That Putnam was the author of the idea there can be no doubt. He had been a land surveyor the greater portion of his life, and must have known from experience the advantages of dividing land in that manner over the old metes and bounds practice that had long prevailed in the colonies.

It would be interesting to know why Putnam was so firmly committed to a 6-mile square township, for in his request for that standard he appears to be somewhat set in his opinion.

The surveyors of the Western Reserve, long after, considered a 5-mile square township to be the proper size, which they subdivided into quarters of 4000 acres each, with the expectation, perhaps, that a further division would be made into sixteenths of 1000 acres and possibly again into 500-acre tracts. This was a good land division, and a plan that would naturally have many supporters with those who gave thought to the subject. It was very simple and semidecimal in feature, but the subdivisions were too large.

It is a question whether the 5-mile township would not have been better than the one afterward adopted. Many modern surveyors would answer in the affirmative. It was about the correct size, and would have been a sort of amendment to Jefferson's first plan by which sections could have been grouped by hundreds.

But the township was necessary, whether it was 5 or 6 or 10 miles square, because the subsequent subdivisions into sections was a natural procedure. The mile was a standard measure or a unit of length, so the square mile became a unit of surface, which could be divided to fractions sufficiently large. A division by sections

alone would soon have become cumbersome, and a larger unit or measure like the township could not be avoided.

The method of public land surveys first assumed a definite and permanent form by congressional action in 1785. At that time the question of raising revenue was paramount, and the wild lands in the West were looked to for that purpose. A committee was appointed, of which Thomas Jefferson was chairman, to submit a plan for putting those lands upon the market. The report proposed, as a preliminary, to divide the territory into tracts 10 miles square, to be called "hundreds," and these, in turn, into 100 squares, a mile in size, to be called "lots." Jefferson's work is apparent in this scheme. The tracts were afterward reduced to 7 miles square, and again to 6 miles. After considering the whole subject for over a year Congress adopted the report as amended, and it became a law, which is known as the Ordinance of 1785.

This is the origin, by law, of the method of surveying the public lands of the United States and the first legislation on that subject. Nothing is known officially beyond this act and who the men were that influenced the legislation, and by what manner or means the result was accomplished will never be known. If we could reveal some unwritten history of about that date the name of Rufus Putnam might be conspicuous and perhaps Hutchins also, for they were both prominent men, of great ability, and possessed character and influence. Their advice would naturally be sought for and appreciated by those who framed the law.

In this act the words township and range appear for the first time. Lots were changed to sections and their numbering made as at present at a later date.

The Ordinance of 1785 provided for the following:

The division of territory into townships of 6 miles square.

Numbering of townships from south to north, beginning each range with No. 1, and ranges to be numbered by progressive numbers to the westward.

All lines to be marked on trees and described on plats.

A plat of each township to be made, "and all mines, salt springs, mill sites, salt licks, water courses, mountains and all other remarkable or permanent things over and near which such lines shall pass shall be marked on the plats, and also the quality of the soil."

Plats of townships shall be marked by subdivisions into lots of 1 mile square or 640 acres, and numbered from 1 to 36. In fractional townships the lots shall be numbered as if the township was entire.

External lines of townships to be marked at every mile with lot corners.

All lines to be run by the true meridian and the magnetic variation to be noted on all plats.

A tract of country west of the Pennsylvania line and south of the Connecticut Lands was directed to be surveyed in this manner, and work was commenced in the early summer of 1786.

The office of Geographer of the United States was created, who was to have personal charge of all surveys, and Thomas Hutchins was appointed to the position. He was the first and only incumbent of that office. One surveyor from each State was also appointed.

Hutchins' record while in charge of the work comprised the survey of that tract known as the Seven Ranges and a small portion of country between the Great Miami and Little Miami Rivers.

It was his good fortune to inaugurate a public work which in time grew to enormous proportions, and became of invaluable benefit to the people of this country, a work whose results will remain for all time. He deserves what credit is his, for he was an accomplished surveyor and had been a brave soldier. In his appointment the Continental Congress made a good selection.

A commencement was made at the south end of the Pennsylvania boundary, on the north bank of the Ohio River, and a line run 42 miles westward, which has always been known as the Geographer's Line. Afterward the country was run into ranges southward to the Ohio River, and then into townships by east and west lines, but it was several years before all subdivisions into lots were completed. Hutchins did not live to see the end of his work, but died while in harness. The surveys were then managed by the Treasury Department and for some years after the beginning of the present Government.

At this time the Indians assumed a hostile attitude, which soon led to a long and bloody war. Immigration came to a standstill and the public surveys also, but after Wayne's decisive victory and the treaty of Greenville, which brought a permanent peace, people began to look again for homes in the Northwest Territory, and what might be called a record era in land surveying commenced.

This was opened by the act or law of 1796, which provided among other things for the survey of all lands not already disposed of, changing the name of lots to sections and introducing the present method of numbering them, and creating the office of Surveyor-General, which was filled by the appointment of Rufus Putnam.

It is not within the province of this paper to give a detailed history of the surveys conducted by Putnam under this law. They

were soon commenced west of the Seven Ranges and also beyond the Great Miami River, but principally in the Military Bounty Tract, and were carried forward as fast as surveyors could perform the work or while there was money appropriated.

For some reason the townships in the Military Bounty Tract were made 5 miles square and subdivided into quarters. This small piece of country is the only instance where the general Government surveyed land in that manner.

About the time Putnam began operations, or a short time previously, surveys were commenced in the Western Reserve, under the general charge of Seth Pease, who was on the ground with a number of parties. The surveyor-in-chief began by running the 41st parallel westward as a south boundary to the Connecticut Lands; then commencing at the eastern end of the Reserve to lay out townships 5 miles square, he worked westward, but it was several years before all the land was divided.

When Surveyor Pease began to number ranges in the Western Reserve, from the Pennsylvania line to the west, and townships to the north from the 41st parallel, he did a very important thing without knowing it. He invented the system of principal meridians and base lines. The Pennsylvania line had been run 12 years before as a west boundary to that State. Pease ran the 41st parallel as a south boundary to the lands owned by Connecticut. They were known to him as boundary lines, yet he made them a principal meridian and base line, something which he could not avoid doing and what anyone else would have done.

Putnam numbered the ranges and townships of the Military Bounty Tract in the same manner. He made a principal meridian of the west line of the Seven Ranges and a base line of the south boundary to the tract. He did not know that he was bringing out an idea which his successor in office would elaborate on a very extensive scale.

If the scheme of establishing 2 main lines for the government of all surveys in an extensive tract of country was original with Mansfield, he certainly must have found its inception in the Ohio surveys when he became Surveyor-General.

General Putnam remained in charge of the Western surveys until the summer of 1803, when he was removed by President Jefferson, and what might be called the second chapter in the history of this work came to an end with his retirement from office.

How much credit should be given to Putnam for the origin of this method? Just about all of it. The pith of the whole system is the division of vacant territory into townships 6 miles square, and

Putnam was the author of that idea. All the other features are merely attachments. The main part of an invention is the principle. He who devises this is the inventor. Others always follow who make improvements, until the invention approaches completion. Whether Putnam completed the method in all its details or not, he first suggested the idea which became the principal part of the whole structure. This is his record on the upbuilding of that structure. If a history of the public land surveys is ever written, the name of Rufus Putnam should stand above all others.

At this period Jared Mansfield took charge of the work as the second Surveyor-General. Jefferson had become dissatisfied with Putnam's manner of conducting the surveys, and had sent Mansfield to rectify errors and introduce something more like scientific method. Putnam had claimed that the lines could be run by true meridian only with difficulty, and that it was as well to use a fixed variation, whether the lines were north and south or not. Jefferson was too educated a man to coincide with this opinion and demanded something superior. Herein is where his work and influence on the early surveys occur, and if he is to be credited with a share in planning the present system, it is in this demand for a better practice and his efforts to obtain it.

What did Mansfield do as a Surveyor-General? This is a difficult question to answer. If he ever told his Government of anything he had done, that report is not available. It is doubtful if there ever was another official of this Government of whose services so little is known. In the whole field of biographical literature the record is silent as to his individual share in building up this edifice. One is sometimes led to believe that it was Jefferson himself who first proposed the scheme of a framework consisting of a 2 astronomically measured lines, and that he sent Mansfield to execute his ideas. In our researches we are able to gather a few scraps of information, here and there, from which we learn very little, but can infer much. We are told in his son's "Personal Memoirs" that he established three principal meridians in Ohio and Indiana while he was Surveyor-General, but this undoubtedly is second-hand information. We know from a report of the Secretary of the Treasury how much money had been expended on public surveys in each Territory up to the end of 1812, the date when Mansfield resigned.

Furthermore, we are given an account of the work, so far as it had progressed to 1817, by some Western writer in "Niles' Register" of that year, but it does not separate Mansfield's work from that of his predecessors.

For the first two years Mansfield remained in Ohio, and con-

tinued the public surveys as they had previously been conducted. There was nothing else he could do, for it was too late to introduce much improvement. He probably ran the correctional meridian from the Ohio River north to the Military Bounty Lands, in order to close up the distorted surveys on the east and to commence correct ones on the west to the Scioto River. He must have ran the Ohio-Indiana boundary line, at least that part of it north of Fort Recovery, as a State line. This afterward became the first principal meridian, and was used for that purpose by Edward Tiffin, who followed as Surveyor-General.

If Mansfield did establish three principal meridians in Ohio and Indiana these lines must have been two of them.

In 1805 Mansfield went to Indiana with several surveyors, and here is where he displayed his scientific acquirements. He made a first commencement with that system of surveying which has been followed for 100 years and continued nearly to completion. He found in Indiana Territory a large tract of country where no one had worked before, entirely removed from the checkerboard work in Ohio, and he proceeded to put his own ideas into execution, with the present second meridian and its base line as a result.

Here is where Mansfield was superior to Putnam or Hutchins. But he had opportunities which they had never known, and was not hampered by the stipulations of any law. He had been given full rein, and let it be said to his credit that he made good use of the privilege. They had considered a tract of country to be a plane surface. Mansfield considered it a spherical surface, and knew that range lines running north would approach each other, with the 6-mile distance apart gradually growing less, which would in time require rectifying. This he did by devising a system of standard parallels or correction lines, which he called parallels to the equator.

Some time after this surveys were commenced on the third principal meridian and later on the Michigan meridian, and there is reason to believe from the writer in "Niles' Register" that he planned the fourth meridian and perhaps the fifth. When he resigned his office the system was complete. His methods have been followed ever since, and extended over the whole vast public domain to the shores of the Pacific.

This is Jared Mansfield's record on the public surveys of this country, and it is certainly a very creditable one.

ADDRESS.

By George T. Wickes, President of the Montana Society of Engineers.

[Read before the Society at its Fourteenth Annual Meeting, Helena, Montana, January 9, 1904.*]

Gentlemen of the Montana Society of Engineers:

Searching for a subject upon which to address you with the hope of interesting you, in way of some engineering proposition or work, has been fruitless. The local engineer's practice rarely yields subjects of interest, save only to those for whom the work is undertaken. I have therefore thought that perhaps I might entertain you for a brief time in giving a few reminiscences, which may have in their favor a little worth in giving an idea of the great changes that have come over the Western country in comparatively but few years.

My earliest far Western experience commenced at Wyandotte, now Kansas City, Kansas, in the years 1862 and 1863.

Kansas City, it now seems to me, could not then have had a total population of over 3500—Wyandotte not half that. Leavenworth was then the metropolis of the "border," from which the freight teams departed in large trains, loaded for the West and for New Mexico. Leavenworth could not have had a population of over 5000. Kansas City *had* evidently seen better days, judging from the then vacant warehouses on the bank of the Missouri River.

Between Wyandotte and Kansas City was a rope ferry over the Kansas or Kaw River, and then a fine stretch of timber land, largely of handsome oaks, but at times not considered a safe place to travel through alone. This was practically on the "border" then, near to the edge of the "Great American Desert," as it was called in the geographies.

Beyond Wyandotte, west 40 miles, was a small settlement called Lawrence; then, a few miles farther, a still smaller congregation of stone houses at Topeka; then came Fort Riley; adjoining this a few saloons, with their usual adjuncts, at Junction City. This was the true "border," 125 miles west from the Missouri River.

Beyond Fort Riley, then the farthest western United States Government military post, and before reaching the Rocky Mountains, was a vast rolling plain, 500 miles wide, and, to the best of my recollection, with not a tree in the whole distance.

This country, however, was covered with a thick matting of

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buffalo grass; a surprising thing, for it grew from a hard-baked surface soil, something like a concrete pavement of to-day. From this hard surface would be emitted a rumbling noise, like the roll of distant thunder, when herds of buffalo were on stampede over it.

There were vast herds of these buffalo, whose numbers I would not attempt to estimate, but I have looked over them, dotting the plains as far as I could see, with a field glass. One was also scarcely ever out of sight of antelope; and at night it would seem as if the infernal regions had opened wide and emptied a howling multitude around us, from the baying and yelping of wolves and coyotes. The presence of Indians was an uncertain matter. One never knew where they were. Perhaps for days there would not be a sign of an Indian in the country; then, all at once, and always in the most unexpected manner, they would seem to rise out of the earth all around; it would be a veritable rising out of the earth, for they would circle around inside the many deep canyons and come up, from all directions, as if they were coming out from holes in the ground.

Five hundred miles of such country did not seem, then, like any 500 that might be mentioned nowadays in any part of the globe. We have become so accustomed to great distances, and to fast travel over them, that it is impossible for the modern man to realize the sensation of starting for a 500-mile ride horseback, or by mule or bull train. Leaving the border and starting for the Rocky Mountains seemed like going out into some vast wilderness, like going into impenetrable darkness in a strange place. It seems impossible, now, that then, at Kansas City, you could find no one that could tell you anything more than rumor about the Kansas Trail, as it was called, which, by the way, was no trail at all.

It was known that John C. Fremont had crossed the country in this general region, and there was a vague rumor that, some years before the time of which I speak, a party of about 200 had gone west from Kansas City, but what had become of them no one could be found that knew.

As I recollect, Fremont left with the railroad people no data which would give any guidance over this country, or any information as to what difficulties might be met with, in surveying or passing over it.

It was *the* Indian country of the West; the "wild Indian" of romance, with the "Noble Red Man" feature left out.

At the time of which I speak there was a remnant of the Wyandotte Indian tribe between Kansas City and Lawrence, and, a little farther west, of the Pottawattamie nation. Some of these, though

really with but little Indian blood left in their veins, were well-to-do, apparently, and, after a fashion, industrious people; but most of them were far different.

While working between Wyandotte and Lawrence I had to stay frequently in the dwellings and settlements of some of these sure-enough Indians, eat the food cooked by the squaws and sleep on the ground or floor, under the only shelter to be had, with Indians rolled up in their blankets around me, giving a fair opportunity, one might judge, to become acquainted with them. The squaws had a peculiarly odoriferous grease that they delighted to use; and the bucks, though they had tobacco, mixed it with dry sumac leaves, which, until one became accustomed to it, seemed like inhaling the smoke of burning red pepper. There was a "Half-Moon," a "Mud-Eater" and a "Sarcoxie" among them, and some of the enterprising ones had a squaw to hoe the corn and get the firewood, and another to do the cooking.

The troublesome Indians were the Cheyennes, Arapahoes and Sioux, who harbored between Fort Riley and the Rocky Mountains, chiefly the two former tribes on the route of our survey. At this time also there were bands of lawless white men, robbers and murderers, always on the lookout for an opportunity to rob, which invariably meant to murder as well, and to apply quick vengeance upon some hated or dreaded individual when caught off guard.

There was also another element, that did not make much noise, that had a quiet business way about them, that helped the courts materially to rid the country from these desperadoes. The local sheriff had not infrequently to cut some fellow down from the end of a string, one end having been used as a cravat, the other attached to the limb of a tree, a jutting log of a house, or even a tall fence rail, in the absence of something more convenient.

This sort of thing ended about 1865 or 1866, when a member from one of these gangs turned against his former comrades and brought the body of one to the settlement, with the story of a hard fight for his life, for the purpose of proving himself not one of the gang. Also, as the railroad progressed and Eastern people began to realize that it was possible for a continental road to be completed uniting the two oceans, immigration began more rapidly to come into the country, of such a stamp as made it less possible for the shrewd lawyers of the day to prove the very questionable alibis for their desperado clients, a game at which they had been so successful. These were the best paying clients of the time. Also, I think, it became unhealthy, as a business proposition for *themselves,* to accept such clientage.

Walking the streets with a large dragoon Colt's belted on the outside of one's coat was so common, that it was unremarkable; and when out on surveys my armament, for instance, was 2 of these Colt's revolvers in the holsters of the saddle, 2 in the boots or on the hips, with a Spencer or Henry rifle (that had come into use since the commencement of the Civil War) over the horn of the saddle. It was apt to be a question of life or death, whether or not a goodly number of shots were immediately ready for use.

Thinking of the times, the surroundings, the customs and daily incidents, it is with hesitation that I write or speak of them, for fear of being thought a romancer; and, when I look about me, and think of the intervening time, I am apt to imagine that the earlier experiences were dreams; but this notion is soon dispelled when some particular incident comes to my mind that makes such a notion impossible. They are mentioned now only to show what marked changes have taken place. The "border," in 1863, was more than 1000 miles east from here. Now there is no "border," save Nome or Bering Strait.

I rarely hear Denver mentioned that my thoughts do not go back to the Denver of the early time, when going in with the preliminary surveys of the Union Pacific Railroad, eastern division, as it was called. This was in 1865; Evans was Governor of the Territory; the whole of Denver then consisted of but 2 streets, Laramie and Blake, and they were but 2 or 3 blocks long.

There were always outfits camped around the settlement, and the streets were filled with miners, plainsmen, Mexicans and the roving roughs that infested the country. I remember passing one of the big gambling houses, either "the Diana" or "the Progress," and seeing a man brought out dead, who had been either shot or killed with a knife. The only ones who seemed to take any interest in the incident were the men who carried the body out, and they, it seemed, merely wished to remove an encumbrance from under their feet; for I went into the house, and all of the many tables were running, with all variety of games, crowds of men around each, many of the toughest looking characters that imagination can picture, and no notice was taken of that one of their number who was being carried out from one of these tables.

You can imagine what it was to bring a survey party of so large a number, all of the true Western type of those days, into a town such as Denver. I suppose that they thought they might take it for their own use for a time; the intrusion was in such a mass (and I know that some of them were of the wildest of the Western breed) that the soldiers from the post, that had been recently established,

came out, to try to bring the place to at least its normal condition. The officer of the day called upon me, and I found that he had a large number locked up, and concluded with him that it might be well to leave them housed until morning. In the morning, after rounding them into camp, another feature of the times commenced to be enacted. It was an election day; vehicles of all kinds and descriptions, from broken-down hacks to prairie schooners, began to arrive, with kegs, etc., in front, and the men were asked to take a ride. It was an especial occasion for a frolic, nothing more; the fellow who gave the most treats was the successful candidate, and it appeared perfectly legitimate that a vote should be cast each time a treat was given, no matter how many times the process had been repeated. Without doubt, the men voted for each candidate at least once, if not several times.

In connection with this, I am reminded of another, though a different kind of experience, still, one that belongs only to those days; but if it could be enacted now, as then, a show like Buffalo Bill's would require nothing else to draw a crowd.

When my survey had reached about 50 miles west from Fort Riley, a party of railroad officials, army officers and their friends came out to my camp from the post for a buffalo hunt. There were about 30 in the party; they were supplied at the fort with good horses, fine enough and fast enough, but not accustomed to see or smell buffalo. But, as buffalo were in great abundance, the fun commenced at once on their arrival. The uninitiated horses would enter into the spirit of the chase after a bull, cow or calf with as much spirit as the wild rider, but so soon as they came near enough to the unusual object and got a sniff of this plains habitant, their course, which had been like a hurricane in the direction of the buffalo, was immediately switched upon a tangent at right angles to the one they had been going; and a kodak would have shown the rider in the air, with arms and legs spread in all directions, but mostly in that of a whirling dip needle. Then a few would stop just long enough to be assured that the victim really had his legs, head and arms together, and could navigate, and on they would go again. It was quite as safe in camp as near one of these riders. The buffalo was in the safest position of all, while the horse was in the greatest danger; for, in one instance, a rider brought his gun down to blaze away at a buffalo in front of him and the bullet went below and between the horse's ears; result, the rider only continued after the buffalo until he came in contact with the unexpected earth. I am happy to say the party all returned to the fort, outside of boxes.

At the time of my arrival in Wyandotte there were two projected lines for Pacific railroads, both subsidized by the Government; one was planned to go west upon the Platte River Valley, starting at Omaha. The franchise for this was then held by Mr. Durant, of New York. The other was to leave the Missouri River at Kansas City or Wyandotte, going west through Kansas. This franchise was originally held by John C. Fremont. Afterward it was transferred by him to Mr. Samuel Hallett, a New York Wall Street broker. Mr. Hallett at that time had rails laid on about 10 miles of road west from Wyandotte.

This was during the Civil War. Men were very difficult to secure to prosecute the work, so that progress in the start was very slow; and I am quite sure that money, for building a road across what was then considered a desert, was also very hard to obtain. It was a scheme that seemed, to most people at the East, of the wildest nature, and most likely never to be accomplished. I remember that we, who were making the surveys, used to speculate as to whether we or our grandchildren ever would see a road that would reach the Pacific Ocean. After seeing the Rocky Mountains at Denver and the Snowy Range, and supposing that these were a fair sample of the whole, it appeared very improbable.

Mr. Hallett built perhaps 15 or 20 miles, when some trouble arose between him and one of the engineers, in regard to a report which Mr. Hallett wished made, and which was thought by the engineer to involve a misstatement of facts. Mr. Hallett abused the engineer, who, in return, shot and almost instantly killed him. This created but little excitement, and in a few days was apparently forgotten. The engineer afterward gave himself up, stood his trial and was acquitted.

Before his death Hallett had interested John D. Perry, and with him Adolphus Meyer, Carlos S. Greeley, Thos. L. Price and Mr. Archer, with some others of St. Louis, in his enterprise. After Mr. Hallett's death, Mr. Perry sent Mr. Bartholow to Wyandotte, who, for a time, had charge of the railroad construction.

Under the latter, having been a rodman for Mr. Hallett, I was continued as such on the line between Wyandotte and Lawrence. I do not remember the exact time when a more responsible position was given me, but I do recall locating the line from Leavenworth to Lawrence, then, beginning near Topeka, and carrying the preliminary surveys through to the mountains, and after, the final location of a portion.

Until the road was completed to the neighborhood of Topeka work progressed very slowly. Then the St. Louis men, and interested

parties in Cincinnati, under the leadership of R. M. Schoemaker of that place, formed a unique company somewhat on this fashion: They divided themselves into 2 parties; 1 consisting of the President and the Directors, the other of the builders, under R. M. Schoemaker as chief engineer and manager. This arrangement worked out very satisfactorily to all concerned. Contracting with themselves was an admirable scheme, and the work was rushed vigorously. I will not trifle with you by saying that our orders were to avoid going through any ant hills, but we *were* to avoid any others if we could get around them. This, though, was before 20° or even 9° curves were considered practicable. Long tangents, though, were not in it. Miles of road were what was wanted; but the country was such that we could get a good alignment on easy grades and with very light work. The Government subsidy of $16,000 per mile, the land grant, and then the privilege of issuing other securities in the way of bonds and stock, made probably a rich harvest for those interested. After all, if this harvest of cash had not been plentiful in the start, who knows what difference it might make now. There is plenty of room for conjecture as to what might have been.

The grading, tie-making and other kindred work was done by men brought from Canada, Americans suited for such service being in the army. These importations were sent out on the line with guns as well as with shovels and picks. If a party of a half-dozen or more Indians made a dash toward them I have known 75 or 100 graders to fling down their guns, with their shovels and picks, and rush pellmell for their adobe houses. Drawing guns to stop them was of no use. In the start, and before they realized what we were up to, the Indians would make these dashes for the fun of seeing these fellows run, and a *possible* scalp. They would turn very quickly if a few subcontractors or engineers started after them horseback. Such chases were apt to be exciting, particularly if one of the pursuers got separated from his friends unawares. The Indians would quickly see this, and would then circle around in a gulch to corral this lone individual; then *he* would have to lie down on his horse and stick the spurs in. Good horses were important at such a time.

The general course of the survey was that of the Smoky Hill River; divides had to be followed, to avoid the deep canyons washed out through the great depth of easily washed surface. The *immediate* surface crust was hard, and would shed water like a roof; but when this water began to gather together into channels, with ever-increasing numbers of streams added, they became mighty floods, that would tear down these gulches as if they would cut through to

the under side of everything; there were great areas for these floods to gather in; now, with the land cultivated, so that rain may be absorbed, such floods are probably rare.

Following the high lands with the road for a long time, getting water was a serious problem; at first, the low places were selected in which to dig wells, but this was unsuccessful. Afterward wells were tried at or near the divide, and water was found at reasonable depth.

We followed these uplands until some of the head waters of the Arkansas and Platte Rivers were reached, and then followed down the Platte branches to Denver.

I recall particularly, and with great vividness, when about at the head of the Smoky Hill River, the first appearance of snow-capped Pike's Peak; it could be compared to nothing so appropriately as to a wonderful emerald. It truly had as great varying color, with a radiance, a radiating beauty, that to me no emerald ever equaled. This magnificent appearance of a stone, with its incomparable luster, was set in a brown plain between it and us; and to the horizon, north and south, all irregularities were lost in the distance. The effect was marvelously beautiful. The mirage, common to the plain, gave a shimmer to the radiant coloring not seen with the real stone.

Our outfits for these surveys had to be very complete, having to provide for necessaries that would cover our wants for 6 months' absence from sources of supply.

Our teams, wagons and tents were obtained from the Government and paid for by the railroad company. I had an order, from Government headquarters at Washington, that any requisition I might make upon any post for supplies, in case of necessity, should be honored.

I have said that Fort Riley was the farthest western post, and so, in a sense, it was, so far as our general route was concerned; but there was a small post on the Arkansas River, 40 or 60 miles south from the course of our survey, called Fort Zarah. I think it was started as an emergency post for supplies, but recently made, and soon abandoned, for I never heard of it after. I had its location given to me, as nearly as possible, and when I supposed we were in its vicinity, concluded, as a matter of safety, to add to certain of our supplies; I therefore took the ambulance, granted to me as engineer in charge, with 4 fast mules and a driver, and started to find the post, traveling somewhat as one does at sea, with a compass. Outside of the painfully disagreeable experience of sleeping for a few hours in a place much inhabited, little of moment occurred to

impress me, save that, while returning at night, that there might be less chance of Indian attack, we had an experience in the way of seeing a herd of buffalo on full stampede. It occurred about midnight. Above the noise of the ambulance I heard the unmistakable rumble and roll of the distant herd. Swinging the leading mules and fastening them to the rear of the ambulance was all that could be done, save to wait. How long this was I cannot say. I could see the black line quite a distance from us, but could tell nothing of the course of the herd, which passed close in front of us, so close that the forms of the bulls on the flank were distinct in every particular. If I were an artist, it seems to me now, I could draw those forms, every line. There were no remarks between the driver and myself, as I recollect, but, after the living avalanche had passed, there *was* a long-drawn sigh of relief. I do not now recall the least other incident, not even arriving at camp, but that rush of the buffalo herd is indelibly impressed upon my memory. A herd of buffalo on stampede is a blind, merciless, overwhelming mass, that annihilates anything destructible within its course. It would destroy a part of itself, if, by any chance, some of its number should fall. Each bull, when stampeding, is a great senseless machine, seeing nothing but its immediate leader, which he follows, with his immense head close to the ground. The rush is by instinct rather than by sight. The objective point is to be reached, no matter what may be in the way. Such herds are led by the largest, strongest bulls. They are flanked by bulls and their rear is brought up by others. I have watched them feeding as well as on stampede. When pasturing they are like an army, with outposts, having 3 bulls as sentinels on every prominent point surrounding the herd; but, on stampede, they have lost all save the sense to rush in close mass in a certain direction, swerving for nothing.

We absolutely lived upon buffalo meat; it was almost bread and meat. To be sure, we had quick-made bread, but that did not count. My recollection goes back to the *perfect* satisfaction of sitting down on the ground with a *stack,* a tin plate *heaped* with nicely fried hump or tenderloin before me, which was none too much to satisfy the appetite, with a quart or two of coffee sweetened with brown sugar.

This was before the tin-can age. We once tried what the men called "desecrated vegetables." These were a desiccated, dried up, apparently hydraulic pressed mass of old cabbage mostly, and any other old thing mixed; but it had one quality that surpasses belief, the way it would swell when put to soak. I think one cake would expand to the bulk of a fair horse feed. When cooked, it was about

as good as eating toothpicks. We gave it up. Our regular meals were at daylight in the morning and just before dark at night, and we carried in our pockets jerked buffalo meat, which we ate, when inclined, during the day, while walking or riding.

This "jerked" buffalo meat is worthy of especial note. All of ours was made from the "hump" and "tenderloin" of the bull. It was cut into strips, about 1¼ inches thick, about 3 inches wide and say a foot long; then it was threaded upon small rope, which was wound around our wagon bodies and bows. Sometimes a wagon would be literally covered with such a fringe. At first a thin, but very strong cuticle would form, which would strengthen and thicken in time, to say about the thickness of blotting paper. Cutting a piece of this meat across the grain, to eat, the inside, unless it was very old, would be found soft, with none of its flavor gone. Even when very old, if properly prepared, it was the delicious meat it was before it had gone through this process of curing.

Conditions now are unquestionably changed, so that it is doubtful whether the same results could be obtained, as there is unquestionably more moisture in the atmosphere now than there was then, and I have no recollection of flies in those days on the plains. Flies, like some other things, have come with civilization, to lay their unwholesome eggs to hatch destructive agents.

Our only fuel was "buffalo chips," and an admirable fuel it was. It seems to me that food, cooked over a fire made from these, had an appetizing flavor that ordinary wood cannot give. I believe no "plainsman" will deny this.

What marvelous changes have occurred wherever one may look! Where I was thankful to have a tent to keep the wolves out, and a sufficient force of men to save our scalps, are now railroads by the thousands of miles; cities, with opera houses, fine hotels and elegant homes; wonderful improvements, inventions and discoveries that have altered conditions of everything that has to do with our daily existence and advancement. To be sure, unwholesome weeds have started to grow, as in the best of cultivated crops. We must make an earnest effort to eradicate these, or our harvest of good things will quickly begin to grow smaller. Only eternal vigilance and unbounded energy can suppress such pernicious growth. But I have unbounded faith in the strength and rightmindedness of our American people, in every walk in life. The aims of the masses are true and elevating; the comparatively few are barnacles and poisonous; and it is my conviction that, though the changes of the past have been great, those to come will be still greater and grander! May you, my friends, participate in the gathering in of these harvests.

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A DESCRIPTION OF SEWAGE DISPOSAL SYSTEMS IN MASSACHUSETTS.

BY X. HENRY GOODNOUGH, MEMBER OF THE BOSTON SOCIETY OF CIVIL ENGINEERS.

[Read before the Society, November 19, 1902.*]

THE modern sewerage system, like many other public services, has been evolved from very crude beginnings.

The first sewers in the State were built in the city of Boston probably more than 200 years ago. These sewers were evidently, for the most part, drains for removing soil or storm water and sink drainage, and were built and owned by private individuals or associations of citizens living on a single street or in a small district. About the year 1823 the city took control of the sewers, but for several years after that time fecal matter was rigidly excluded from them. In 1857 there were 6500 water-closets connected with sewers in Boston, and in 1885 about 100,000. The history of sewerage in the other large cities and towns in the State is probably similar to that in Boston. Sewers were at first chiefly drains for the draining of streets or wet places, the removal of standing water and the drainage of cellars, and the principal sewage they received came from sinks.

After the introduction of public water supplies in the cities and towns sewers came into more general use, and their proper construction and management became of importance. Twenty years ago, however, there were still only about twenty cities and towns in this State which were provided with sewerage systems. At the present time ninety-four cities and towns in the State have fairly complete systems of sewerage.

* Manuscript received March 21, 1904.—Secretary, Ass'n of Eng. Socs.

The method of disposing of sewage in all cases was to discharge it into the nearest body of water—whether river, pond or harbor—and little heed was given to the conditions existing about the outlet. As the quantity of sewage discharged at these outlets increased they came to be commonly very serious nuisances.

About thirty years ago the advantages of keeping sewage separate from storm water were recognized, and at the present time the combined system of sewerage is very rarely used in this State in the construction of new systems. On account of the necessity for purifying sewage the combined systems in some cities and towns are being reconstructed in order to separate the sewage from the storm water.

Where sewage is discharged into a large river or into the sea, well away from the shore, in such a manner that it becomes thoroughly diluted before returning to the shores, danger of nuisance may be avoided, and many cities and towns situated on the seacoast or along the larger rivers effect a satisfactory disposal of their sewage in this way.

The sewage of the Metropolitan district, for example, is efficiently disposed of at Deer Island and Moon Island into tidal currents, and fouling of the shores is avoided. At Moon Island the sewage is stored in reservoirs and discharged on the outgoing tide in such a manner that it does not come back on the returning tide. At Deer Island the 50,000,000 gallons of sewage per day brought down by the sewer are discharged continuously into a strong tidal current, and, whether the tide is rising or falling, this sewage is disposed of effectually within the space of a square mile and does not affect any inhabited shore.

In some of the inland cities and towns situated on the larger rivers sewage is efficiently disposed of by direct discharge into the river. Serious local nuisances exist, however, at many of the sewer outlets into streams at the present time owing to their faulty location or construction. These outlets are usually placed at the bank of the stream at the edge of high water, where danger of injury from freshets is likely to be avoided, and at times of low water in the river in the summer season, or when the water is held back by dams during the night or on Sundays or holidays, very serious nuisances are created by the collection of sewage upon the exposed bottom of the stream.

The objectionable conditions caused by such outlets can be prevented by carrying the outlet a sufficient distance into the stream, so that the sewage becomes thoroughly mingled with the water before it can return to the bank.

When combined systems exist it is not essential that all of the sewage and storm water be carried out into the stream, and experience has shown that, if the dry-weather flow is carried to some point of discharge well away from the bank of the stream, the mingled sewage and storm water may be allowed to overflow at the edge of the stream without creating objectionable conditions.

Successful outlets of this sort are in operation at Springfield, where at several of the sewer outlets a pipe of sufficient size for the removal of the dry-weather flow of sewage is carried from the sewer a short distance back from the outlet out under the river bed to a distance of 200 to 300 feet from shore, so that sewage is rarely visible in the neighborhood of the outlet and the fouling of the banks is avoided. At times of rain the mingled sewage and storm water discharges through an overflow at the edge of the river bank, but the quantity of sewage discharged in this way is very small compared with the total flow and no nuisance is created.

The most serious nuisances, however, resulting from the discharge of sewage into streams and inland waters are those resulting from the discharge of so large a quantity of sewage in proportion to the flow of the stream that the river is rendered filthy and offensive for a long distance below the outlet.

The effect of the discharge of large quantities of sewage into the small streams had frequently been illustrated as early as 1885, and in 1887 the experiments of the State Board of Health, with the special object of studying methods of purifying sewage and preventing the pollution of streams, were begun at the Experiment Station at Lawrence.

At the time these experiments were begun, fifteen years ago, very little was known anywhere with regard to methods of purification of sewage. Sewage farms were in existence in England and on the Continent of Europe, but the method of disposal was, in most cases, that of irrigation, and the quantity that had actually been disposed of had reached perhaps 10,000 gallons per acre per day.

The earlier results of the experiments showed very conclusively that sewage could be purified efficiently by filtration through sand or gravel, at rates depending to a considerable extent on the character of the material, but, with ordinary sands and gravels found in our valleys, at rates ranging from 40,000 to 80,000 gallons per acre per day.

In 1889 the first system for the purification of sewage by intermittent filtration upon any considerable scale in this State was constructed at Framingham, upon lines indicated by the Lawrence experiments, and was followed two years later by systems at

Gardner and Marlborough, which have been in successful operation since that time.

The total number of cities and towns now provided with sewerage systems in the State is about ninety-four, of which about one-fourth dispose of their sewage by some system of purification; thirty-five discharge into the sea and the remainder into inland streams.

While the results of investigations at the Lawrence Experiment Station early showed the feasibility of purifying large quantities of sewage by filtration through sands and gravels, found commonly in the valleys of the State, investigation was early directed to the practicability of purifying sewage at more rapid rates than it was found possible to maintain with the ordinary sand filter.

The organic matter in suspension in sewage has been the chief source of difficulty in its purification, on account of the clogging of the surfaces of filter beds, and most of the investigations upon rapid methods of purification of sewage have dealt with processes of getting rid of this organic matter in some manner—by straining or precipitation or reducing it to simpler forms.

By passing sewage through a settling tank and allowing from two to four hours for sedimentation it has been found that about 30 per cent. of the organic matter can be removed, but the sludge has still, of course, to be disposed of. By chemical precipitation about half the organic matter in the sewage can be removed, but, in addition to the cost of chemicals, the sludge problem still remains. Both of these methods are, however, used to advantage in some cases.

It was discovered early in the investigations that a rapid change takes place in sewage after the mixture of the waste waters and the discharges from the fixtures in dwelling houses, stores and offices first takes place in the sewers.

Much clean water finds its way into sewers by waste from fixtures in houses and by leakage through defective joints and cracks in the sewers and tributary house drains; and fresh sewage may contain dissolved oxygen, but the oxygen is subsequently used up and the organic matters in the sewage become broken up and finely divided, and after remaining for a considerable time in the sewers, or passing through a tank or reservoir, the character of the sewage is greatly changed.

About seven years ago the results of experiments made in England upon the effect of storing sewage in a tank for a period of about twenty-four hours were first published, showing that by allowing sewage to pass continuously and very slowly through a

closed tank the organic matters became broken up, decomposition and putrefaction set in, and a reduction took place in the quantity of organic matter. Much gas was evolved in this process and apparently very little sludge or sediment accumulated in the tank. This process of treating the sewage, so as to avoid the problem of dealing with large quantities of sludge, is known as the septic tank process.

At about the same time came the discovery of the contact filter. This, as usually constructed, is a filter containing coarse material, with an outlet controlled by gates. It is operated by filling it with sewage in frequent applications during a period of several hours, and subsequently, after allowing it to stand full, by draining it off. By first passing sewage through a septic tank and subsequently through contact filters, rates of filtration were maintained for a time far higher than with sand filtration.

More recently still has come the intermittent continuous filter—a filter composed of coarse material, to which sewage is applied in comparatively small and frequent doses, and allowed to run freely through the filter and out at the outlet.

Careful experiments have been made at the Lawrence Experiment Station for several years upon the operation of all of these processes of sewage purification, and very interesting results have been obtained.

It is not my intention to discuss the septic tank or the contact or intermittent continuous filters, since none of these methods of sewage purification is employed upon a large scale in Massachusetts.

It may be said, however, that the experiments which have thus far been made in the use of the septic tank with some sewages bring the sewage into such a condition that it is extremely difficult to purify it by any subsequent process. Moreover, sewage stored in a septic tank has generally an extremely foul odor as compared with ordinary sewage. It has also been found that sludge accumulates in septic tanks, and that it is necessary to remove this sludge at longer or shorter intervals.

Experiments with contact beds have shown that it is difficult to secure material with sufficient open space which will resist breaking down, and that there is a tendency in such beds for the open space to become clogged, reducing the capacity of the filters, a very serious matter if it reaches such a point as to make it necessary to renew the material.

The results of experiments upon the operation of intermittent continuous filters are very interesting, but there has as yet been very little opportunity for experience in the operation of experi-

mental filters of this kind. These studies are of the greatest interest and importance, on account of the necessity of finding some suitable means of purifying sewage in places where sand and gravel areas are not readily available. In Massachusetts, however, lands containing sandy or gravelly soil are found commonly in our valleys, and the cost of disposing of the sewage by intermittent filtration where such lands are readily available is, in general, less than by any of the processes thus far developed, and a more thoroughly purified effluent can be obtained by sand filtration than has thus far been found practicable by any of the processes indicated.

FRAMINGHAM.

Population in 1900 11,302

As already stated, the first sewage disposal system of importance constructed in Massachusetts for the purification of sewage was that at Framingham. This town is situated partially within the watershed from which the supply of Boston was drawn at the time the works were built, and a portion of the cost of the works was defrayed by the city, on the consideration that the disposal works should be located outside of the watersheds from which the city's water supply was drawn.

The sewage is collected by means of a system of separate sewers, discharging into a collecting or storage reservoir, about half a mile from the village; thence the sewage is pumped a little over two miles to the filtration area.

About 100 acres of land were purchased as a sewage disposal area, and upon this area about 20 acres of filter beds were prepared by leveling the land and taking off the loam and a portion of the subsoil to form embankments between the filter beds. The subsoil remaining on the surface of most of these beds is quite fine—much finer than in most of the other filtration areas in the State. Beneath the subsoil coarse gravel is found for a depth of several feet. Two main underdrains were laid beneath some of the beds which discharge the small amount of effluent which they collect upon the ground outside of the beds, where it is again filtered for the most part before entering Bannister Brook, which receives the effluent. The sewage is applied to these filters at an average rate of about 700,000 gallons per day, or 35,000 gallons per acre per day. The sewage is very strong, and is at times highly colored by manufacturing waste. The beds dispose of all of the sewage, and no unpurified sewage is discharged into the streams.

For several years corn has been grown upon these filter beds.

Fig. 1. Framingham. View Showing Filter Beds at Time of Harvesting Crop of Corn.

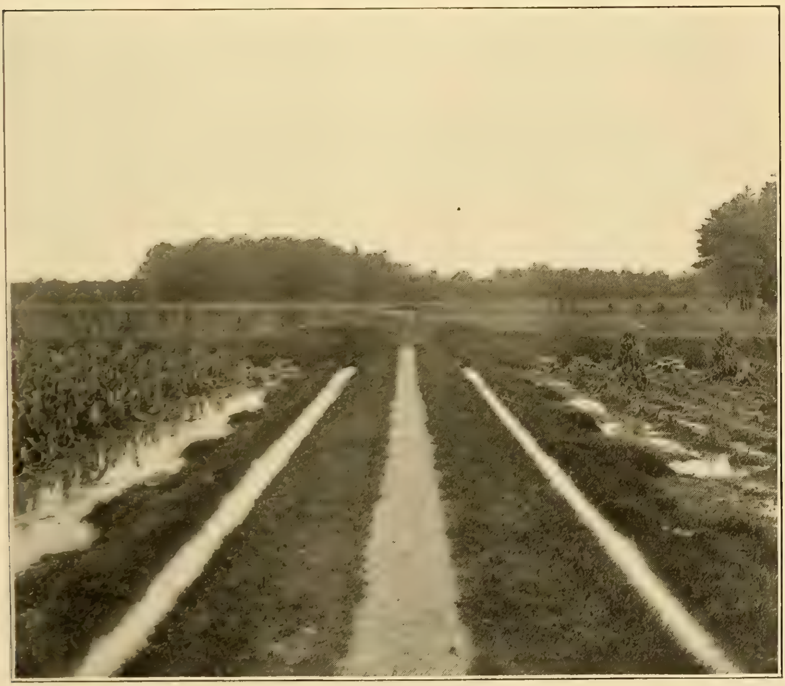


Fig. 2. Framingham. One Method of Distributing Sewage on Filter Beds.

FIG. 3. FRAMINGHAM. ANOTHER METHOD OF DISTRIBUTING SEWAGE ON FILTER BEDS. THE SURFACES OF THE FILTER BEDS REMAIN IN THE CONDITION SHOWN DURING THE WINTER, THE ICE AND SNOW RESTING ON THE CORN HILLS.

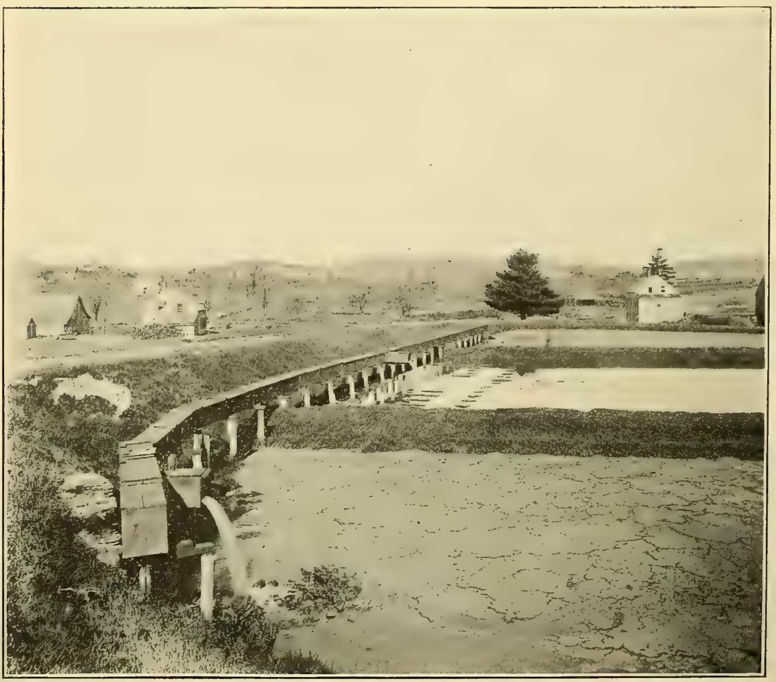


FIG. 4. GARDNER. VIEW OF FILTER BEDS, SHOWING THE ACCUMULATION OF SOLID MATTER ON THE SURFACES.

The corn crop is sold at auction early in the fall, and the purchasers are required to cut and remove the stalks. After the removal of the crop nothing further is done to the land until the following spring, when it is plowed and again prepared for planting. All of the sewage, including the sludge, is discharged upon the filters, and no accumulations upon the surface of the filter beds are removed except at times in the spring.

GARDNER.

Population in 1900 10,813

A sewerage system in the central portion of the town was constructed in 1890, the sewage being conveyed to a filtration area in the valley of Pond Brook, south of the village. Subsequently, a sewerage system was constructed in the westerly portion of the town and the sewage conveyed to a new purification works situated in the town of Templeton, south of the Otter River. All of the sewers are built upon the separate plan, but considerable storm and ground water find their way into the sewers.

The average quantity of sewage delivered to the older filtration area amounts to about 400,000 gallons per day, increasing in wet weather to 800,000 gallons per day. All of the sewage is conveyed to the filtration area by gravity. The total area purchased was 19.4 acres, and the total area of filter beds thus far constructed 2.7 acres, most of which are very thoroughly underdrained. The sewage is received in a settling tank, from which it flows to the different filters, the sludge being disposed of upon sludge beds, where it is allowed to dry and subsequently removed, some of it being used as a fertilizer. The beds are not of sufficient capacity for the purification of all of the sewage during periods of high flow, especially in the spring, and much sewage is discharged unpurified into Pond Brook.

The new system for West Gardner is also constructed upon the separate plan, and in this system also the flow of sewage is increased greatly at times by leakage and by storm water which find their way into the sewers. The sewage is conveyed by gravity to the filtration area, where it is first passed through coke strainers and subsequently applied to sand filters, nine in number, having an aggregate area of 2.25 acres, which are thoroughly underdrained. The quantity of sewage amounts on an average to about 300,000 gallons per day. A portion of the solid matter is removed from the sewage by the coke strainers and is deposited nearby, much of it being used subsequently as a fertilizer. There are four strainers, having a combined area of one-fourth of an acre.

MARLBOROUGH.

Population in 1900 13,609

The sewers are constructed upon the separate plan, but much leakage and storm water finds its way into them, enormously increasing the flow at certain seasons of the year. The average quantity of sewage amounts to about 1,000,000 gallons per day, while the maximum quantity is probably as much as 4,000,000 gallons per day. The sewage is conveyed by gravity to the filtration area, located about 4 miles from the central portion of the city. Forty-nine acres were purchased by the city, upon which twenty filter beds and six sludge beds, having an aggregate area of 11.7 acres, have been prepared for the purification of the sewage, all of which are thoroughly underdrained. Sewage is received in a settling tank, in which a portion of the solid matter is removed, the sludge being discharged upon sludge beds and subsequently removed and used as a fertilizer upon lands in the neighborhood. A portion of the sewage is discharged untreated in times of wet weather, especially in the spring, into a neighboring brook.

CLINTON.

Population in 1900.................................13,667

The sewers are built upon the separate plan, but some storm water finds its way into them, and there is much leakage into the sewers in the wetter portion of the year. The average flow is about 625,000 gallons per day, but in wet weather it is as high as 1,600,000 gallons per day. The sewage is delivered to a pumping station, where it is received in a reservoir intended to hold the night flow, from which it is pumped in the daytime to filter beds in the town of Lancaster.

The total area of filter beds is 22.5 acres, divided into twenty-five beds. The soil is very coarse and porous, and the level of the ground water was originally many feet below the surface of the beds, so that a limited amount of underdrainage has been found sufficient for the removal of the effluent.

At periods of very high flow sewage is sometimes wasted into the river at the pumping station, but otherwise all of the sewage, including the sludge, is discharged upon the filtration area, the effluent from which flows into a small stream tributary to the Nashua River.

BROCKTON.

Population in 1900.................................40,063

The sewers are constructed upon the separate plan, but the flow is considerably increased by leakage in the wetter portion of the

Fig. 5. Gardner. Cleaning a Filter Bed.

Fig. 6. Gardner. View of Coke Strainers, Showing also Sand Filter Beds in the Distance.

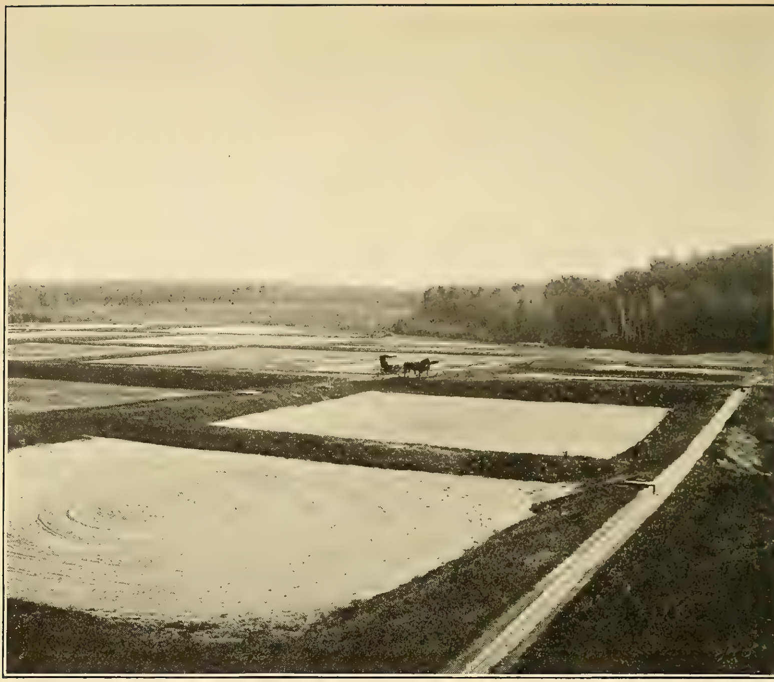


Fig. 7. Marlborough. General View of Filter Beds.

Fig. 8. Clinton. View Showing Method of Applying Sewage to Filter Beds.

year. The quantity amounts on an average to about 700,000 gallons per day. The sewage flows to a pumping station at the lower end of the city, where it is received in a reservoir intended to hold the night flow, from which it is pumped to the filtration area in the westerly part of the city, where 39 acres have been purchased, upon which 21.5 acres, divided into twenty-three beds, have been prepared for the purification of the sewage. The soil of the filtration area is very coarse and porous, and a sufficient amount of underdrainage has been provided for the removal of the effluent. A few of the beds are used as sludge beds to receive the heavy sewage which settles at the bottom of the tank, and which is drawn out therefrom at the last part of the day's pumping. Much solid matter collects on the sludge beds, which is removed and used as a fertilizer. The remaining beds require very little care.

ANDOVER.

Population in 1900 6,813

The sewers are constructed upon the separate plan, and have received thus far very little surface or ground water leakage, the average quantity of sewage amounting to about 125,000 gallons per day. The sewage from the greater portion of the town is conveyed to the filtration area by gravity, but the sewage from low areas in the valley of the Shawsheen River cannot be delivered upon the filter beds by gravity, and this sewage is pumped to the main sewer.

The town has purchased 30 acres of land for sewage purification purposes, upon which 4.2 acres of filters, divided into twenty beds, which are thoroughly underdrained, have been prepared for the purification of the sewage. The sewage is received into a settling tank, in which a portion of the heavier matters, or sludge, is allowed to settle, and is subsequently discharged upon sludge beds prepared for the purpose. The sludge, after drying, is removed from the beds and either deposited in low ground or used as a fertilizer.

SPENCER.

Population in 1900 7,627

The sewers of the town are constructed upon the separate plan, but many roofs have been connected, and the flow is increased considerably at times by storm water and by leakage. The average quantity of sewage amounts to about 375,000 gallons per day.

The sewage is conveyed by gravity to a filtration area, which comprises 22 acres, upon which 9.3 acres of filter beds have been prepared. The soil is very coarse and porous, and a very few

underdrains have been found sufficient for the removal of the effluent. All of the sewage is discharged directly upon the filter beds, which are raked from time to time when necessary, the small amount of solid matter being used as a fertilizer or deposited in the neighborhood.

SOUTHBRIDGE.

Population in 1900.................................10,025

The sewers are mainly constructed on the separate plan, but considerable storm and ground water find their way into them. The average quantity of sewage amounts to about 350,000 gallons per day. The sewage is conveyed by gravity to a filtration area, where 7.25 acres of filter beds have been prepared for the purification of the sewage, divided into seventeen beds, which are thoroughly underdrained. A settling tank has been provided for receiving the sewage, but has not, thus far, been used to any considerable extent. At times of wet weather much of the sewage is allowed to discharge unpurified into the Quinebaug River below the filter beds.

CONCORD.

Population in 1900.................................5,652

The sewage is collected into a separate system of sewers, the flow in which is greatly increased by leakage. The average flow at the present time is about 375,000 gallons per day. The sewage is collected into a reservoir near the Concord River, designed to hold the night flow, from which it is pumped to the filtration area, which comprises 14 acres of sandy land, upon which 3.3 acres of filter beds, divided into four beds, have been prepared for the purification of the sewage. The material is porous, and the level of the ground water a considerable distance below the surface of the beds, and no underdrainage has thus far been provided. All of the sewage is discharged upon the filter beds, and no attempt has been made to separate solid matters from the sewage.

WESTBOROUGH.

Population in 1900.................................5,400

The sewage is collected in a separate system of sewers, and flows by gravity to the filtration area, which comprises about 32 acres, upon which seven filter beds, well underdrained, aggregating four acres in area, have been prepared for the purification of the sewage. The average quantity of sewage amounts to about 200,000 gallons per day, but this flow is increased to about 600,000

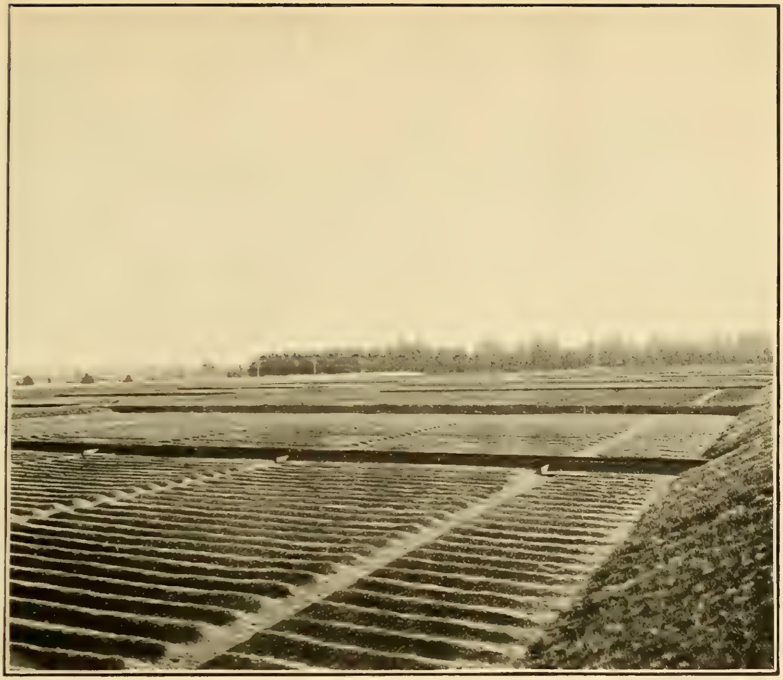


Fig. 9. Brockton. General View of Filter Beds.

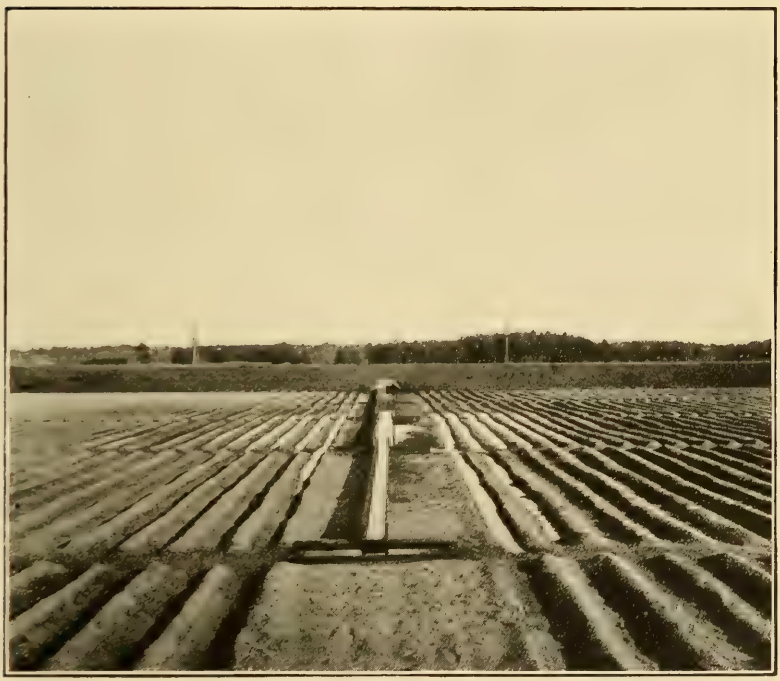


Fig. 10. Brockton. Method of Applying Sewage to Filter Beds.

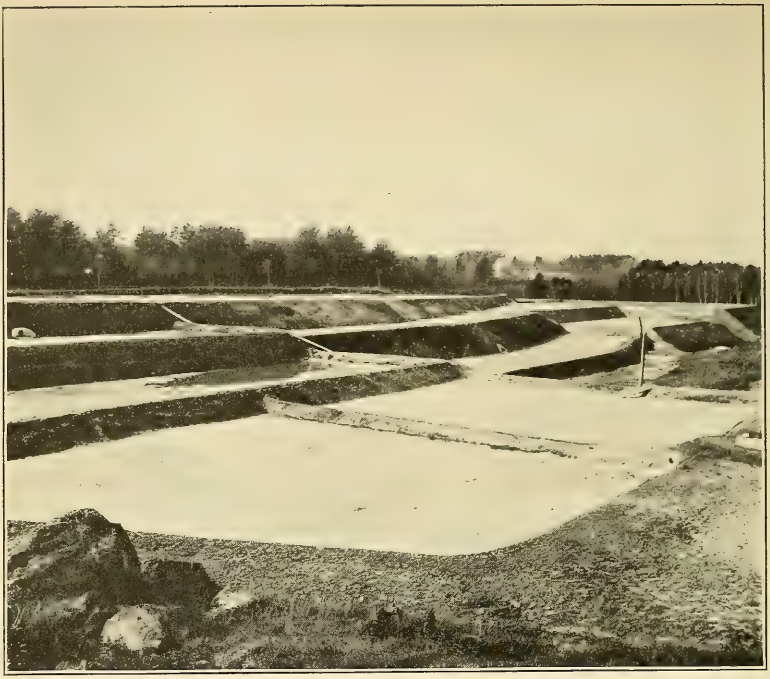


Fig. 11. Andover. General View of Filter Beds.

Fig. 12. Spencer. General View of Filter Beds.

gallons per day at times of wet weather, owing to leakage into the sewers.

At the filtration area the sewage passes through a small tank, in which a small quantity of solid matter is removed from the sewage before applying it to the filter beds.

NATICK.

Population in 1900 9,488

The sewers are constructed upon the separate plan, but a great quantity of ground water leaks into the sewers at certain seasons of the year. The average quantity of sewage amounts to about 600,000 gallons per day, and the maximum quantity to 2,200,000 gallons per day. The sewage is conveyed to a pumping station, near the southerly end of Lake Cochituate, whence it is pumped to a filtration area adjacent to that of the town of Framingham. About 97 acres of land were purchased by the town, upon which six filter beds, each 1 acre in area, have been prepared for the disposal of sewage. The beds are thoroughly underdrained, the underdrainage flowing into Bannister Brook, above the underdrains of the Framingham filtration area. All of the sewage is pumped to the filter beds, and no attempt is made to separate sludge from the sewage.

LEICESTER.

Population in 1900 3,416

The sewers are built only in the main village, and are constructed upon the separate plan, the average daily flow amounting to about 20,000 gallons. The sewage is delivered by gravity at a filtration area, comprising 9 acres, upon which seven filter beds, having a combined area of 0.35 of an acre, have been prepared, all of which are underdrained. At the filtration area the sewage is received in a large settling tank, the contents of which are occasionally discharged upon a special sludge bed, from which the sludge is removed after drying, and used as a fertilizer or deposited in the neighborhood. In addition to the filter beds there are two long trenches, into which sewage is occasionally discharged.

In addition to the filtration areas of cities and towns already described there are many such areas in use for the disposal of the sewage of public institutions which are of much interest. Among these are the sewage disposal areas at Danvers Lunatic Hospital, Foxborough Hospital for Dipsomaniacs and Inebriates, Westborough Insane Hospital, Rutland State Sanatorium and the State Hospital for Epileptics at Monson. There are also many areas in

use for private institutions, among which may be mentioned the filtration area used for the purification of the sewage of St. Mark's School in Southborough.

The Danvers Lunatic Hospital had a population in 1900 of about 1300. The total quantity of sewage amounts to about 150,000 gallons per day, which is delivered by gravity upon the filtration area, consisting of ten filter beds, aggregating 2.8 acres in area, all of which are underdrained.

The Foxborough Hospital for Dipsomaniacs and Inebriates contains about 200 people. The sewage is discharged by gravity upon four filter beds having an aggregate area of 1.12 acres. All of the sewage is discharged upon the filters, no attempt being made to separate sludge from the sewage.

At the Westborough Insane Hospital the sewage of 700 persons, amounting to about 80,000 gallons per day, is purified upon 3 acres of filter beds, which consist of very coarse soil. Underdrains were laid beneath these beds but no effluent has ever been collected in them.

At the Rutland State Sanatorium the sewage of a population of about 250 persons is discharged upon twelve small filter beds, aggregating 1 acre in area. This area receives little or no care, but all of the sewage is efficiently purified.

At the Monson Hospital for Epileptics most of the sewage is used for the irrigation of crops, but a small area of excellent filter beds has been prepared for use at times when the sewage cannot be disposed of by irrigation.

At St. Mark's School, Southborough, all of the sewage is disposed of on several small filter beds not far from the school.

FIG. 13. SOUTHBRIDGE. GENERAL VIEW OF FILTER BEDS.

FIG. 14. WESTBOROUGH. GENERAL VIEW OF FILTER BEDS.

Fig. 15. Leicester. General View of Filter Beds.

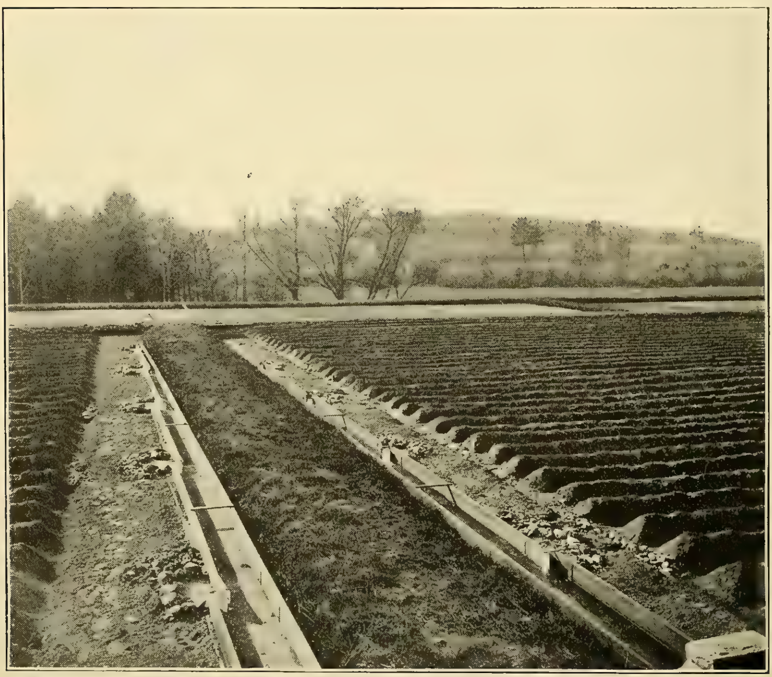


Fig. 16. Danvers. Danvers Lunatic Hospital. View of Filter Beds Prepared for Winter, Showing Method of Applying Sewage.

ADAPTABILITY OF THE MASSACHUSETTS METHOD OF INTERMITTENT SAND FILTRATION TO SEWAGE DISPOSAL PROBLEMS IN OTHER STATES.

By F. Herbert Snow, Member of the Boston Society of Civil Engineers.

[Read before the Society, November 19, 1902.*]

In discussing the subject which has been assigned to him, the writer proposes to allude to four typical problems outside of the State of Massachusetts, and, as introductory thereto, to touch upon the part which the Massachusetts State Board of Health has taken in developing and placing the art of sewage disposal upon a scientific basis.

EARLY HISTORY.

The outdoor closet or cesspool plan was the primitive system of household waste disposal. Next came the dry-pail method, involving the utilizing of the solids as a fertilizer. In fact, prior to the water-carriage system, which comprised the next step in the development of the art, soil was looked to as the only final means of disposal. But upon the general introduction of sewerage systems, the wastes of communities thus served were discharged into bodies of water which were supposed to be able to purify themselves, but which did so in part only. In consequence of this pollution, and to obviate it, the next step in the art was recourse to the purifying power of land, upon which, in many instances, sewage was required to be spread broadcast and utilized to fertilize crops. This method of disposal was called "irrigation." A later modification of it was called "intermittent filtration." Meantime, various methods of treating sewage had been invented, having for their prime object in every instance the removal of the solid matters from the main body of the liquid by such means as mechanical appliances or settling tanks, with or without the use of chemical precipitants, to facilitate the final purification of the sewage on land or to clarify and render it suitable to go into a body of water.

The exact process of purification taking place in the ground was not understood at this time. As far back as 1838, the germ theory of fermentation and decay had been advanced, and Pasteur, in 1860, had established it, but its significance in relation to practical sewage disposal matters was not grasped. But in 1870 it was demonstrated that there existed micro-organisms which were active

* Manuscript received March 21, 1904.—Secretary, Ass'n of Eng. Socs.

in a soil upon which sewage was turned, and in 1872 the scientific world accepted the fact that sewage matter was converted into nitrates by organisms present in normal sewage and soils.

By 1884 several scientists had demonstrated that oxidation of organic matters in sewage, when treated by irrigation or filtration methods, was caused by bacterial action, and not solely by chemical action, as previously supposed to have been the case.

This knowledge—that bacteria played an important part in assisting oxidation—was followed by efforts to facilitate conditions under which these activities occurred, and it was at this stage of the development of the art that the Massachusetts State Board of Health began its now world-renowned classical researches.

MASSACHUSETTS' CONTRIBUTION TO THE ART.

In reviewing the history of filtration in Massachusetts, we find, as early as the fourth annual report of the State Board of Health that the conditions of the Blackstone River, below Worcester, were therein noted and the possibility of disposing of the sewage of that city by intermittent filtration outlined.

Later, in the special report of 1876, it was pointed out that factory refuse and trade impurities were a great cause of pollution of streams, but that sweeping laws for the general and immediate purification of all these sewages were hardly justified in the then present state of knowledge of the subject. Nevertheless, the Board recommended that no city or town be allowed to discharge sewage into any water course or pond without first purifying it by irrigation.

The next year the Board recommended that no liquids of a deleterious character from new manufactories be discharged into a stream unless purified according to the best available means.

It is interesting to observe that there were then in use in England 59 sewage farms, 26 chemical precipitation works, 16 filtration fields, 10 plain subsident tanks and 3 intermittent filtration systems.

In 1882 the Board submitted a report to the Legislature on a definite plan of disposal of Worcester's sewage, recommending intermittent filtration. That city, however, successfully objected to being forced to embark on "a course of expensive experiments with little promise of success." Four years later an act was passed to establish a disposal system which, without limiting Worcester to any particular method, required the city within four years to purify the sewage so that it should not create a nuisance or endanger public health. This law materialized in the shape of a chemical precipitation plant, which was completed and put into operation in 1890;

three years later it was doubled in size, and in 1896 was reported by State officers as being inefficient to prevent the pollution of the Blackstone River. It was stated in the State Board of Health's report for that year that the pollution would increase until some more complete purification of the sewage was made; whereupon the town of Millbury brought suit to force Worcester to properly purify its sewage, and the court issued a favorable decree. Since which time the works have been enlarged and a few sand filters have been added.

In order to obviate local and selfish determination of sanitary questions, the Legislature of 1886 thought best to provide outside and dispassionate control of water supply and drainage problems, and the act of that year, entitled "An act to protect the purity of inland waters," marked the beginning of a new era in State sanitation. The law committed the general oversight and care of inland waters to the State Board of Health, and conferred power to employ experts and do various things, among which should be noted:

"1. The advising of cities and towns, corporations and individuals as to the most appropriate source of water supply and best method of insuring its purity and disposing of sewage.

"2. The chemical and other examination of water supplies and other inland waters.

"3. The collecting of information on purification of sewage on land and conducting experiments on such purification as are necessary to obtain knowledge for immediate use within the State."

The recommendation of the Massachusetts Drainage Commission that the Mystic Valley sewage be filtered on the Saugus marshes, and that in the upper Charles and Neponset and the Sudbury and Cochituate basins twelve independent intermittent filtration and irrigation systems be established, had much to do with the starting of the well-known important series of experiments at Lawrence. The report of the Board for 1888 states that on the basis of results of filtration experiments and practical experience in England and on the Continent, where various intermittent filters are reputed to be treating sewage at a rate of 36,000 to 90,000 gallons per acre daily, "We must enter upon experiments to determine the amount of sewage we can in this climate purify with such material as is deposited in our valleys. This knowledge can be obtained only by trial and careful observation, and to obtain reliable information and actual additions to the knowledge of the world upon this subject . . . . for an immediate and urgent use in this State . . . . the Board established the experiment station at Lawrence, and has begun the study of soils, sands and gravel to be found in the vicinity and after-

ward to be replenished by those which may be proposed for use in other localities."

The experience gained by these experiments on intermittent filtration of sewage through different soils early proved of efficient service in enabling the Board to decide many difficult problems presented for consideration by authorities of cities and towns, as fully appears in the annual reports, and as years went by, the act to protect the purity of inland waters proved to be one of the most useful laws in the history of State legislation. The work performed under its provisions by the State Board of Health has justly won a reputation among engineers, sanitarians and experts in this and foreign countries as standard work upon water supply and sewage disposal.

In 1889 the Board reported in regard to the disposal of sewage of the Mystic and Charles River Valleys, "upon additional information obtained by experiments and investigations of the past year, the Saugus marshes will not serve for a filtering area for the sewage of the Mystic Valley, and, as there is no other area available, its disposal by filtration must be abandoned."

The same year experiments on chemical precipitation were made, and in 1891 some work was done with manufacturing wastes. The next year investigation of purification of sewage containing dyestuffs as undertaken, and the report of the Board for that year contains descriptions of sewage fields built under its advice.

During 1893 experiments were begun upon rapid filtration of sewage from which sludge had been removed. Sludge removal by screening through gravel and coke, by sedimentation, chemical precipitation and mechanical devices were studied.

In 1895 the first experiments were conducted upon disposal of waste liquors from paper-making, wool scourings and tanneries. The next year fresh and stale sewage were specifically discussed and emphasized in the report, and two filters were put in to illustrate the difference in disposal.

In 1897 some studies of filtering manufacturing sewages were conducted away from the Lawrence Station, to find out if these sewages could be filtered and purified by the same processes successfully applied to ordinary sewage.

The report for 1898 goes on to say that the experiments on purification of sewage and various kinds of manufacturing wastes "has furnished new and useful information upon the practicability of purifying sewage at rapid rates and with various materials which are of value in many sewage disposal problems where land suitable for purification of sewage cannot be obtained."

Two septic tanks were started in operation at the Lawrence

Station that year. The term septic was attributed to the publication of certain English experiments. The report of the Board for the next year, during which year attention was paid to rapid methods —septic tanks and bacteria or contact beds—states that the "results of the septic tank process taken in connection with contact beds give promise of furnishing a means of purifying sewage in places where suitable land for the purpose is not available."

Thus reliable information upon the subject of the amount of sewage that can be purified in this climate with such materials as are deposited in the valleys was obtained and made public.

In England, where natural sandy deposits are not so available as here in Massachusetts, the septic tank system and contact filter systems have been perfected and used, and these methods have come to be considered and known as English methods, and intermittent filtration has come to be known and talked about as the American or Massachusetts method.

THE PROBLEM AT SARATOGA SPRINGS.

Coming to the adaptability of intermittent filtration to problems outside of Massachusetts, we will first consider Saratoga Springs, N. Y.

The normal population of this place is 12,000, and its summer population is at times over 40,000. In consequence of this fluctuation the seasonal changes in amount and quality of the sewage are unusual. The problem was still further complicated by a combined system of sewers and an abnormal water consumption.

An almost ideal territory for filtration was found, but to reach it required pumping.

Natural sand areas possible to reach by gravity were found to contain some clay intermixed with fine sand, which rendered their utility doubtful.

The estimated cost of a high-rate artificial plant on the most available gravity site proved to be in excess of the cost of the sand filter project finally adopted. By way of explaining this project, attention is called to the fact that there are certain features which demand special consideration in every problem.

One of these features relates to the handling of the solids. They may be removed from the bulk of the sewage by sedimentation, or by chemicals, or by liquefaction, or by mechanical devices. In each process the sludge is concentrated for further handling and disposal.

Liquefaction may be the cheapest method in some cases, because the solids in suspension are dissolved to a greater or less extent thereby, and to this extent effect economy in their subse-

quent treatment. These dissolving actions take place even in the sewers, but the bacteria which promote the process do not attain their greatest activities unless the sewage is brought to rest. The septic tank is a settling basin in which this period of rest is prolonged for this purpose and the solids are intentionally retained for an indefinite time.

At Lawrence the deposits in a tank after two years' operation were practically nothing, while the solids which entered the tank would without septic action have filled the tank five times.

When the sewage is suitable, this process of preliminary treatment of the solids and the liquid prior to the sewage going into a filter has much to commend it for consideration, and it was adopted in the Saratoga design.

Another feature demanding special consideration is the manner of effecting purification of the bulk of the sewage in the body of the filter.

If the dose of sewage is greater than the air capacity of the filter, which air capacity depends upon the size of the sand grain, there will be insufficient oxygen to promote the activities of the nitrifying bacteria, and consequently the filter will store up organic matter and in time become foul and useless.

Where there is an unlimited area of field or sandy plain, it matters not so much whether the engineer is ignorant or careless of the physical qualities of that particular soil and its maximum capacity to purify sewage; but where the filter has to be built of selected material brought from a distance, or in a locality on a side hill or uneven ground, where every cubic yard of material to be moved means considerable expense, the full capacity of the sand should be known and its maximum use planned for in the design.

It is along these lines that advancement in design is to be looked for.

The size of sand grain also has everything to do with the frictional resistance, which must be relied on to hold the sewage long enough to effect purification and yet not too long to hinder the maximum work of the filter.

It is therefore made plain that the dose of sewage should be proportioned to the sand capacity. This is a most important detail of design and also of operation.

Given in any particular case the size of the sand grains and a knowledge of the capacity of that class of sand, the arrangement for a corresponding dosing of the filter can best be secured by providing a chamber or chambers holding the requisite quantity of sewage and operated automatically.

Another feature for special consideration is the quality of the sewage. The amount of work to be performed in the filter is the total amount of organic nitrogen in the applied sewage to be transformed into nitrates. This varies greatly in different sewages. Its importance more particularly relates to the mode of preliminary treatment to be chosen.

Due consideration of these features resulted in the adoption of the Saratoga design, which comprises a station over a pump well at the end of the new outfall sewer, three centrifugal pumps operated by electricity, a receiving reservoir for prolonged sedimentation at the disposal fields, an aërating device for the effluent from the reservoir, an automatic dosing chamber, distributing channels for the sewage and 20 acres of sand filters.

THE PROBLEM AT LAKEWOOD, OHIO.

At Lakewood, Ohio, there were no natural sand deposits available. Sand might have been dredged from the lake, but the cost of doing this would have been excessive.

The choice of a system of disposal lay between a chemical treatment and a high-rate bacterial plant. The latter was selected on the score of adaptability and economy. It comprises a septic tank and cinder contact beds. To regulate the gravity flow to the tanks there are provided automatic orifices. Aëration of the septic effluent is effected in a chamber for that purpose, and a distribution of sewage at the beds and the collection of the effluent and its subsequent discharge into the river is done by means of gates automatically operated, so that no attendant is necessary.

The tanks hold 600,000 gallons. The beds cover $\frac{5}{8}$ of an acre, and are divided into five units.

Bacteria beds are structures in which, under conditions favorable to their existence, the organisms upon which the purification of sewage depends can grow and thrive.

These conditions imply the presence of dissolved oxygen in the sewage and the entrance of air through the entire depth of the bed between the doses of sewage. To make this possible the material must be coarse enough to reduce capillarity to a minimum and at the same time fine enough to intercept the comminuted particles of the organic matter.

The limit of size of bed material, as proved by experience, is from $\frac{1}{16}$ to $\frac{1}{2}$ inch, expressed in diameter of extreme particles. An extended and particular study of available material at Lakewood, supplemented by chemical and mechanical analyses, resulted in the selection of cinders from a large manufacturing plant and the re-

moval and rejection of the dust by a special screening device and the crushing and screening of the larger particles into proper sizes.

In operation four of the five beds are worked at one time, the fifth being thrown out of commission for periods of rest of a week or more. Of the four beds in use, one is filling, one is standing full, one is emptying and one is resting. The automatic mechanism not only effects this distribution at a great saving in cost of labor, but does it with a regularity impossible of attainment by manual manipulation.

THE PROBLEM AT MARION, IOWA.

This city built a system of sewers in 1893 with an outlet into Indian Creek. Suits for pollution of the stream were soon instituted and damages were awarded for depreciation of rental value of pasturage farms, the testimony going to show that cattle refused to drink the water and that other water had to be procured for the stock at great difficulty. In 1899 the writer went to Marion to see about plans for disposal works, and subsequently a high-rate straight-acting automatically operated intermittent coke cinder filter was designed (there being no sands available in this vicinity) embodying the preliminary treatment of the sewage by the septic process. The plans were duly adopted, and in 1900 the city proceeded to construct the septic tank.

The plant in its entirety was not designed to effect a high degree of purity. The stream at the point into which the effluent discharged had a watershed of about 75 square miles, and 3 miles below it entered the Cedar River, the intervening territory being sparsely settled and the creek water unused for domestic purposes.

Four nitrification beds, each $\frac{1}{10}$ acre in size, were proposed Suitable sands could not be obtained, so coke cinders were selected, effective size 1.62 mm., coëfficient of uniformity 2.63, with a total air space equal to 40 per cent.

By an arrangement for the continuous discharge of the septic effluent into a dosing tank of 10,000 gallons' capacity, and the intermittent dosing of the four beds by an automatic siphon, and gates operating automatically, the sewage being delivered onto the surface of the beds by carriers, it was thought that an effluent would be obtained of sufficient purity to meet necessary local conditions. But for economic reasons the city constructed only the septic tank. It holds 150,000 gallons, and the flow from 2000 people connected with the sewers is approximately 200,000 gallons daily, so the time of passage of the sewage through the tank is about eighteen hours' duration.

The effluent is discharged into a stream whose minimum flow, 1.5 cubic feet per second, equals 0.75 cubic feet per second for 1000 people contributing sewage to the tank. The operation of this tank under these interesting conditions seems to be perfectly satisfactory to all concerned.

THE PROBLEM IN THE BRONX RIVER VALLEY, N. Y.

This beautiful valley, in close proximity to New York City, is destined to become populated with a prosperous class of people, and when that time shall have arrived undoubtedly a general sewerage system will have been adopted, comprising the conveying of all the sewage away from the valley and its disposal in connection with New York City sewage into tidal water. But at the present time the cost of such a general system is far beyond the financial resources of the valley, and therefore some other solution of the problem is demanded.

The city of Mount Vernon is in this valley. It has a population of about 25,000 people. Its sewage is discharged into the Hutchinson River, a tidal estuary of Long Island Sound.

The watershed of this river at the sewer outlet is only 7 square miles. About four-fifths of the population of this city use the sewers, so the pollution of the stream is very great.

A plan was projected to extend the outfall sewer to the Sound, and a route was chosen through Pelham Manor, New Rochelle and by Glen Island, so that these places could connect, but a bill authorizing the scheme failed of passage in the Legislature, because of the opposition of these places.

Along the shores of Long Island Sound, affording a possible site for tidewater disposal of Mount Vernon's sewage, there are communities, rapidly increasing in population, of a class which demands the maintenance of the highest sanitary standards, and it is reasonable therefore to conclude that the opposition to the discharge of crude sewage along their foreshores by a foreign municipality is of a permanent character.

Accepting this conclusion, the place to erect and operate clarifying works, if such a solution of the problem is to be sought, would naturally be the nearest available site to the present outlet into tidewater. Here the river joins the government canal, in which the tide rises and falls 7 feet, and its volume is sufficient to dilute a partially purified effluent, but not an effluent from which the suspended matters have been removed by a mere mechanical process.

Another plan which provided for the disposal of Mount Vernon's sewage and other places was projected. But it was abandoned,

owing to its excessive cost. It comprised the construction of an intercepting sewer in the valley of the Bronx, beginning at the village of White Plains and finally joining with the city of New York system.

In view of the probability of an ultimate general sewerage system for all the communities in the valley, any other plan should be considered as a temporary expedient and the ultimate abandonment of any structure erected thereunder should be contemplated.

At this juncture the question must arise as to the kind of a plant best adapted to these peculiar conditions. It is not the duty of State officials, having jurisdiction in questions of public health of this kind (which, because of their nature and extent, pass out from and beyond the control of local boards of health), to devise particular plans for any case, any more than it is the duty of local boards of health to devise a sewage disposal plan; the powers vested in the State department being largely of an advisory character.

The responsibility of the body or individual designing a plan is not lessened by the superior advisory or sanctioning power of the State, but it is just as great to thoroughly comprehend the problem and to devise or adopt the plans best calculated to accomplish the work. This fact is too often overlooked by City Councils. Plans have been adopted in places because they were approved by the State department, which department would undoubtedly have approved other plans better adapted by far to do the work had such plans been presented for consideration and approval.

In the case in question, the right solution of the problem calls for the exercise of the highest knowledge in the art of sewage disposal. A plant is called for whose time of usefulness is limited and whose ultimate abandonment is almost a certainty; during this period it must not create a nuisance; it need not completely purify the sewage; the degree of purity a plant may safely attain and not create a nuisance is involved in this question, and the permissible degree of pollution of the stream into which the effluent of this plant is to go is also involved.

Failure to properly comprehend these features and adequately provide for them in the design involves probable failure of the plant.

In spite of these facts the local government determined to advertise for propositions from owners of proprietary methods, the propositions to be received under general plans and specifications, to be prepared by the city's consulting experts.

The general plan provided for the purchase of 16 acres of land

at the existing sewer outlet. Subsequently $40,000 were paid for this tract. The sewage of the greater part of the city can be delivered to it by gravity flow, but certain areas are so situated that the sewage from them will require pumping. For this purpose the plan contemplated the installation of several small pumping plants at points most economical for the collection of the sewage from these areas and the raising of the sewage to the nearest point in the main conduit which serves the gravity district. The pumping units were planned to be operated by electric power derived from a power plant to be installed in the proposed power and crematory house at the disposal works. This part of the general plant was intended to be permanent in character, as were also the crematories provided for the disposal of city garbage and refuse and sewage screening and sludge.

The method of treatment of the sewage was, of course, left for bidders to propose, but the general specifications called for some kind of bacterial treatment, and the plant was required to have a daily capacity of 2,000,000 gallons of normal town sewage.

The village of White Plains, located in the same valley, has treated its sewage by chemical precipitation for a number of years.

The effluent of this plant has not been satisfactory. The decision of the court in respect to this matter was that the discharge from the works produced at times a foul and offensive odor and added to the discoloration and pollution of the Bronx River.

In view of the issues in the case—which case was most persistently fought through to the highest tribunal of the State—and the decision of the court, which was adverse to White Plains, it became necessary in planning new works to provide for obtaining a high degree of purity of effluent. But because this degree of effluent might never be actually required, since in this instance an effluent clear and odorless, though containing some of its original organic matter and bacteria, and though unsafe to drink, should answer all practical purposes, the plan proposed comprised two parts, one of which it was proposed should be built and operated to effect a substantial but not complete purification.

The question would then become one of fact whether such an effluent contributed in a material and practically measurable degree to the pollution of the river. If so, then the second part of the plant should be added.

This illustrates how the degree of purity a plant should attain may enter into a problem and affect the cost of the same. The first part was estimated to cost $70,000 and the second part $30,000 more.

The general scheme was similar to that proposed for Mount Vernon in respect to the ultimate abandonment of the works for treating the sewage; also, in so far as practicable, the money needful for immediate expenditure was to be put into permanent structures. For instance, the village needed a garbage disposal plant. Therefore, it was proposed to take advantage of the benefits resulting from the combination of sewage and garbage disposal to as great an extent as possible by locating the crematory at the present works, remodeling these works and thereby reduce by half the amount of labor otherwise necessary to operate independent garbage and sewage disposal plants.

This part of the project was intended to be permanent.

The plan, so far as it related to the disposal of sewage, involved the use of the present works as far as possible and the changing over from the mechanical process of chemical treatment to the natural process of bacterial treatment, on the score of saving in cost of operation and improvement in character of effluent.

To maintain the old works in operation during the five previous years about $10,000 were annually expended, and in spite of this outlay the plant proved unsatisfactory. It was estimated that the new works could be built and operated to give good results at a total annual cost for investment and operation of less than the total annual cost of enlarging and operating the old works.

SUMMARY.

The four types of problems cited in the foregoing discussion were, in their solution, closely related to the oxidizing principle of sewage purification, the authority for whose use in this country is found in the Massachusetts experiments.

Thus, in the Bronx River Valley case, while mere slow intermittent sand filtration was not feasible, owing to lack of available sand deposits and suitable territory, modifications of this oxidizing and bacterial process were found to be cheaper and better adapted to the requirements than any mere mechanical process. This was equally true with respect to Lakewood, Ohio, and Marion, Iowa.

The Saratoga problem is, of course, a straight out-and-out slow intermittent sand filter plant, with some novel features added to facilitate operation and insure success under the abnormal conditions obtaining especially with respect to the severity of the winter climate. This plant is thought, by the writer, to be a pattern of excellence in several particulars. Intermittent sand filtration is the only really reliable method of bacterial treatment of sewage to-day. Its limitations are known, and wherever feasible its adoption should

be advocated. But where the local conditions preclude its use, the engineer is forced to consider some one of the new and accelerated methods. Undoubtedly they can be made successful, but they are a more highly organized means of treating sewage than the ordinary sand filter, requiring more intelligent attention and being less capable of meeting fluctuations in quality and quantity of sewage, such as occur daily in many sewerage systems.

SEWAGE DISPOSAL SYSTEMS.

Discussion of papers of X. H. Goodnough and F. H. Snow, before the Boston Society of Civil Engineers, November 19, 1902.

MR. HARRISON P. EDDY.—I have been very much interested in the papers which have been read to-night, but I was not quite prepared for the obituary of the Worcester plant, and consequently failed to bring my apology for appearing here.

The estimated present population of Worcester is 127,500, based on the past growth for a period of fifty-five years. The amount of sewage treated daily during the fiscal year 1902 was 13,300,000 gallons, including storm water, limited in quantity only by the capacity of the outfall sewer. The dry-weather flow (June, July and August) averaged 11,260,000 gallons per day, amounting to 88.3 gallons per capita. The total cost of operating the plant, not including interest or sinking fund accounts, was $50,576.69, making the per capita cost 40 cents. The purification plant has cost approximately $500,000 to date, and about $1,000,000 have been expended in remodeling the sewerage system to facilitate the work of disposal.

Although Worcester is credited with being a very selfish city, it has probably spent more money in the attempt to abate the nuisance in the Blackstone River than has been spent in sewage disposal by any city in the country, except possibly very large cities which dispose of sewage into tidewater. Worcester was unfortunately situated, at the time the sewage disposal problem came up for final action, in that it had a combined system of sewers; not only that, but its sewers had been discharging throughout the city into a trunk sewer, which was originally a brook or river, flowing, in dry weather, about 5,000,000 gallons in twenty-four hours; in freshet, 200,000,000 or 300,000,000 gallons. These features have constituted real difficulties; financial as well as engineering difficulties.

In 1890 the city of Worcester began to operate a chemical precipitation plant. It did not take care of the entire flow of sewage. It was deemed wise to begin with the treatment of the sewage rather

than the reconstruction of the system, for various reasons. In 1893 the plant was increased, and has been increased from time to time ever since. First, minor additions, then more basins for precipitating the sewage; then a plant for taking care of the resulting sludge, and eventually the introduction of filter beds, some of which are now being built. It was impossible to treat the whole of the sewage so long as it mingled with this river, and consequently the city has just completed the building of two intercepting sewers, at a cost of about $1,000,000. In addition to this it will be necessary, before the entire flow of sewage can be treated in time of storm, to have a complete separate system of sewers, so as to take the sewage without installments of storm water, or to greatly increase the size of the purification plant. One or the other must be done if all the sewage must be treated at such times. You can readily see that with 150 miles of sewers this is somewhat of a problem, a financial problem at least. Other difficulties have been encountered there. Worcester is a manufacturing city; there are tanneries, and their sewage has its effect more particularly upon the chemical treatment than the filtration. There is, however, one quality of the Worcester sewage which makes it different from that of most cities in this country, and that is its acid nature. Worcester's largest industry is a branch of the American Steel and Wire Company; large quantities of wire are dipped in vitriol, and the resulting sulphate of iron is turned into the sewer to a large extent, although some of it is recovered and utilized. As much as 100 tons of copperas could be made from the liquors that are found in the sewage waste in a single day; that, however, is exceptional, the average being considerably below that. I mention this merely to show that there is some difficulty in the way of handling successfully the problem at Worcester. Not only is the copperas serious as to chemical treatment—although it is of some benefit—but it is a handicap in that much sludge is produced, and it is a very serious element in the filtration of sewage. When this copperas or sulphate of iron comes through the series of settling basins, not having been treated with chemicals, very little of it is removed from the sewage. It is then turned onto the filters and they succeed in removing quite a portion of the iron. As high, during certain periods, as 50 per cent. or more of this iron is precipitated in the filter largely in the upper portion, in the form of sulphide of iron, sometimes in other forms, oxide of iron, etc., and it seems to be quite a factor in the clogging of the upper layers of the filter.

There are some interesting things in connection with this precipitation or clogging of the iron in the filter, I think, as at certain

times and in certain conditions of the filter the iron is washed out to a limited extent, and it leaves a large amount of suspended oxide of iron in the water, which, of course, makes it rather unsightly. The amount of oxide of iron contained in the sand, after being used for some time, will run as high as 4 or 5 per cent. by weight, and this reduces in the first 6 inches or 1 foot down to less than 1 per cent., and the lower portion contains comparatively little iron. So much for what constitutes the problem at Worcester.

The chemical precipitation plant has been in operation—as I have stated—since 1890; it has cost a great deal of money, as has been mentioned, but under the circumstances it could not readily be abandoned. I think those who best appreciate the problems there to-day feel that there is grave doubt if it can be abandoned in the future for methods which we now know of. Numerous experiments have been made there from time to time, and among others is one of some interest to us, that of the septic tank. It has been found that the action of bacteria directly or indirectly—probably indirectly—causes precipitation of the iron from the soluble form to the suspended, in the form of sulphide of iron, and it is not, perhaps, too much to hope that a tank might be so constructed that this iron would be to a large extent removed from the sewage by the septic process; on the other hand, precipitated in that finely divided form, it is very easily oxidized back to the sulphate, in which state it is readily dissolved by the water and carried out of the septic tank and onto the filters. A large tank, holding about 350,000 gallons, has been used as a septic tank for a time. The results obtained with this acid sewage do not vary greatly from those of domestic sewage; there are some minor details of variation. The effluent from the septic tank running under the conditions which have been tried is exceedingly offensive.

The population in the vicinity of the tank is growing; new houses are being built from time to time in the immediate vicinity, so that the problem of odors is one to be seriously considered. The problem of odors from the septic tank—as considered there—is not so serious as the problem arising from the odor given off by the water as it is spread upon the filters. The area of the septic tank—even though it is not covered with scum—is comparatively small, but when this amount of water is turned out onto the filters it is exposed to the air, and there is a very large surface of water from which the offensive odors can arise.

I don't know that I can add anything more that will be interesting. I shall be very much pleased to see this Society in Worcester at some time to visit our works. They are still in operation!

Chemical Examination of Sewage and Effluents.

		Sewage.	Chemical Effluent.	Filtrate
Ammonia	Free	2.254	2.320	1.082
	Albuminoid Total	1.121	.524	.083
	Albuminoid dissolved	.375	.394	.083
	Albuminoid Suspended	.746	.130	.000
Nitrogen as	Nitrates	—	.157	.454
	Nitrites	—	.0349	.0189
Oxygen consumed	Unfiltered	15.25	6.90	0.76
	Filtered	8.80	5.62	0.76
Chlorine		12.48	11.31	10.55

Note.—An average of 150,000 gallons of chemical effluent have been filtered per acre per day.

The above are the average analyses of sewage, chemical effluent and filtrate from the filter beds for the last fiscal year.

Prof. L. P. Kinnicutt.—I am sure that we all feel greatly indebted to Mr. Goodnough and Mr. Snow for the two interesting papers that we have heard to-night, and we all feel proud of what Massachusetts has done and is doing toward solving the various problems of sanitary science.

There is no question that the world owes to Massachusetts the process of intermittent filtration for the purification of sewage; for, though it was known as early as 1865 that the putrefying substances in sewage could be removed by filtration through sand, it was the work of the Massachusetts State Board of Health that proved that this method of treating sewage was practicable on a large scale. Mr. Goodnough has shown us this evening how widely this method is now used in Massachusetts, and with what excellent results. Still, as Mr. Snow has said, this process is unfortunately not by any means always possible; it requires not only a comparatively large area of land, but also land of the right character—*i. e.,* sand of a certain size and uniformity—and when this does not occur in the near neighborhood of a town or city, that town or city must use other methods of sewage treatment.

As to the process of intermittent filtration, if the plant is well designed and carefully operated, it is sure to give good results; but no greater mistake can be made than to leave a well-constructed plant to the care of an untrained man, and, in my opinion, no better use could be made of a part of the money received by the Board of Health from the State than to employ a thoroughly trained man, whose whole time should be given up to visiting the various intermittent filtration plants in Massachusetts, watching the working of these plants and showing how they should be operated.

The newer methods of treatment, methods for towns or cities where intermittent filtration is not possible, are the result of investigations made in England, and experimental work in England is done on a much larger and more practical scale than in this country. The experimental septic tanks at Manchester and Leeds have a capacity of over 20,000 gallons; the experimental contact beds that I have seen in England were never smaller than one-seventieth of an acre, and ran from that size up to one-half an acre (the size of those at Birmingham), and the experimental percolating filters are also built on the same large scale. Is there not in this a lesson for us?

Contact beds when well designed and carefully operated are successful. The only question is the cost of maintenance, and this depends upon how long a contact bed will continue to work before the filling material will have to be removed and washed. Personally I think the danger of permanent loss of capacity has been exaggerated.

The continuous intermittent or the percolating filter is the newest method for treating sewage. These filters certainly treat a very much larger amount of sewage per given area per day than any other sewage purification process. The effluent though containing suspended matter (which, however, is only slightly putrescible) contains a very large amount of nitrogen in the form of nitrates. Under certain conditions I am persuaded that percolating filters offer the best and cheapest method of removing the putrescible substances from sewage, and I am not sure but that in certain places in southern New England they could be used to advantage, though I doubt if in northern New England the results would be satisfactory during the winter months.

I have already taken too much of your time, especially at this late hour of the evening, and I will only say one word more, and that is, that though we are well on the way toward satisfactorily solving the problem of the treatment of domestic sewage, yet there is still room for investigation and study, especially as regards sewage containing large amounts of manufacturing waste.

Mr. Freeman C. Coffin.—The pictures on the slide recall some of the first work that I did in connection with sewage disposal. The engineer in charge of the designing and construction of a sewerage system at Marlborough had very little precedent to follow in designing the filter beds, and it was a good deal like working in the dark. The system was designed in 1890 and built in 1891. The tank which received the sewage—curiously enough—was in some respects quite similar to the present septic tank. The sewage came in about at the flow line, and was held by a partition in the tank,

over which it flowed in a thin stream. After that it flowed through a screen and passed out into the outlet sewer. The sludge was deposited in this tank above the partition, and the conditions there were such that it could be drawn off from the bottom of the tank by gravity onto the sludge beds. I have not known much about the operation of these beds. I believe that they have been entirely successful, and the area, according to the figures given, has not been increased since the original installation. I was somewhat surprised at this, as I thought it had been increased.

In following the discussion to-night it has occurred to me that sometimes difficult problems of sewage disposal are connected with very small plants. Last year I was asked to design a system for disposing of a small amount of sewage, about 7000 or 8000 gallons a day. The conditions were these: The sewage must be disposed of on the premises. (It was for a school in Wellesley, in a thickly settled part of the town, with something like 100 to 150 inmates.) The sewage was originally disposed of, or supposed to be disposed of, by a subsoil system, which was totally ineffective; the crude sewage was flowing into a stream. The Park Commissioners notified the authorities of the school that this must not continue. It was expected that the town of Wellesley would have a public sewerage system within a short time, and it was desired to avoid expense as much as possible. The conditions for disposal of this sewage without committing a nuisance and without polluting the stream were very difficult. The grounds were limited, something like two acres, which included the buildings and all the grounds they had. There was in my opinion no possibility of disposing of the sewage effectually by any subsoil system. It was rather difficult to determine what to do, but eventually the following plant was designed and constructed: a regular sand filter, entirely artificial, and in connection with it, for preliminary treatment, a coke strainer following out the suggestions of the experiments of the State Board of Health. It was designed on as economical lines as practicable, knowing that it was possible that the capacity of the plant would have to be increased. The sewage is taken into a small pump well and pumped by a gasoline engine, direct connected to a centrifugal pump. A septic tank was considered, but on account of the danger of odors it was not adopted. The plant was covered with a roof above the ground. One of the disadvantages I have found with a filter bed under a roof compared with outdoor beds is that there is no drying off of the sludge under a roof, which makes the sludge problem more difficult. I was somewhat disappointed in the action of the coke filter that it did not remove any more of the sludge. The coke filter was designed for a

rate of about 1,000,000 gallons and the sand filter for about 300,000 gallons per acre per day. This plant went along all right until last spring, when I was notified that it would not work, that the underdrains were all clogged up and no sewage could get through. An examination was made, and it was found that there had been no removal of the sludge from the surface of the beds and the filter was completely choked up. After investigating the matter and asking many questions we were informed by the man who had it in charge that their method was not to remove the sludge as directed, but to dig it over and let the sewage through; when this failed they got a negro to come there and run a bar down in different places until the sewage disappeared. They kept it going until about the first of May in that way, when they could not make it go any longer and the sewage began to run out over the sides of the bed, and they sent for me. About a food of sand and sludge was removed and the filter put in good order again. We left written directions as to how the plant should be operated, and it went along all right until this fall, when we were notified again that it would not work; that they had carried out the instructions carefully, but it would not go. We examined it again and the same conditions were found to exist, although not quite so bad. There were about 3 inches of sludge to be raked off. I don't know what the results now are, but aside from these times it has taken care of the sewage very satisfactorily, and there was no odor, except possibly a little inside of the roof from the pump well. I hope that if it is handled properly it will keep going until the town provides a public system.

Mr. F. P. Stearns.—I have not studied at all carefully the methods of sewage disposal which have been advanced in recent years; but, from what I have read and heard regarding them, and particularly from the statements which have been made to-night by Mr. Goodnough, I feel that it will not be necessary for the present, under the conditions which generally obtain in Massachusetts, to consider at all fully anything but intermittent filtration. In nearly all parts of Massachusetts there are suitable conditions for this method of disposal.

As I cannot add anything of value to the discussion of methods, I will present a summary of the results obtained with the works for the disposal of sewage by intermittent filtration built by the Metropolitan Water Board at Clinton. These works include intercepting sewers, a receiving reservoir and pumping station and $23\frac{1}{2}$ acres of filter beds in a territory of upwards of 100 acres. The cost of these works, exclusive of land damages, was $104,000, and including land damages, which, owing to the circumstances, were excessive in com-

parison with the actual value of the land, about $142,000. The cost of pumping the sewage for the last three years has averaged $2300 per year, and of maintaining the filter beds, screeens and sewers $2400 per year. Several buildings were included with the land taken, and the revenue for rent received from these buildings and from other sources amounts to $400 per year, so that the net annual expense, exclusive of fixed charges, is $4300. The fixed charges may be reckoned at 5 per cent. on the cost of the works, equal to $7100 per year, making the total annual cost, including fixed charges, $11,400. As the town of Clinton has a population of about 14,000, the cost of disposing of the sewage by this system, which provides a thorough purification of the sewage, is about $0.81 per inhabitant, which does not seem to be an unreasonable price for disposing of the sewage of an inland town.

Mr. Geo. A. Carpenter.—I have been pleased with the papers read to-night and with the slides shown upon the screen. I have been impressed in particular with the large areas used by, or at the disposal of, the various cities and towns of Massachusetts in which sewage disposal systems have been constructed, as compared with the area in use in my own city, Pawtucket, R. I.

In Pawtucket we have been studying the problem of sewage disposal by intermittent sand filtration since 1894, and have also conducted some experiments with the septic tank.

Only a portion of our sewers, 13.22 miles, are in the section connected with the filter fields. The population within the territory sewered is about 7300, but the population actually connected is only about 5100. Last year an average of 133,000 gallons of sewage per day were treated, the maximum for a month being 171,000 gallons per day.

The sewage is very strong, averaging 1.41 parts of albuminoid ammonia per 100,000, and comes to the plant fresh from the connections, with very little time for any breaking up of the organic matter or for any septic action before reaching the collecting tanks. It is domestic sewage almost wholly, there being no large amount of manufacturing wastes present.

We have had in actual service 2.35 acres of sand beds and are now constructing 1 acre more. The original area is divided into 13 beds of varying size. Four of these beds are known as sludge beds, and receive the settled sewage from the lower 6 inches of the tanks at a rate of 80,000 gallons per acre. They are dosed in rotation and sewage is applied to each of these sludge beds every fourth day.

The remaining beds are also dosed in rotation, but at a rate of

100,000 gallons per acre. Figured on the basis of 365 days in the year, these beds have received the equivalent of about 64,000 gallons per acre per day for each day in the year.

The effluent from the sand beds shows a removal of 92 per cent. of the organic matter in the original sewage, as represented by the albuminoid ammonia, and shows the presence of 2.71 parts of nitrates per 100,000.

No matter what the method of treatment may be, except direct disposal into tidewater, there will always be a certain amount of sludge, varying with the strength of the sewage, which must be handled in some form. My experience would indicate that the sludge obtained by sedimentation and drawn off each day upon sand beds is more easily handled than in any other form.

In ordinary weather, from the last of April to the middle of November, sludge collected and treated in this way will quickly dry out, losing a large percentage of its moisture. After that it can be raked from the surface of the sand and composted, buried, or burned, if proper facilities are provided. During the winter season the sludge cannot be as conveniently handled in this way. If turned on sand beds it does not readily dry out, but accumulates in large quantities on the surface, and after repeated dosing is apt to throw the bed out of service altogether.

Right here, it seems to me, the septic tank may perhaps be introduced with profit. The septic effluent, freed from a large part of the matter in suspension, can be readily disposed of on the sand beds, and the accumulating sludge—and I believe it will be found that sludge *will accumulate* in all cases with a domestic sewage of any considerable strength—can be taken from the tank in the spring and then disposed of.

Sludge from the septic tank is much more offensive and more difficult to handle than sludge obtained by sedimentation which is raked each day from the surface of the sand. But the septic tank will relieve the sludge beds in winter weather, the most trying season, and in this way may be made a valuable addition to a plant for the disposal of sewage by intermittent filtration.

An interesting peculiarity noticed in the action of the septic tank was the steady accumulation of sludge in the bottom of the tank for the first four months, until about 30 per cent. of the capacity was thus occupied. Upon measuring the sludge the next month it was found that it had risen from the bottom and now floated at the surface, and that the amount had been reduced, in one instance, about 40 per cent. and in another about 28 per cent. The first time this reduction was noticed it was presumed some mistake had been

made, but a repetition of the measurements proved that they were correct.

It would seem that in the operation of the tank the sludge gradually settles to the bottom, where it is acted upon by the bacteria, is gradually lightened and finally rises to the surface. It seems probable that at such times a considerable amount of the matter in suspension may pass off in the effluent, which would account for the reduction in the quantity of the sludge which was observed.

It should be stated in this connection that the septic experiments were made in one of our settling tanks, having an area of 3000 square feet, but the depth at which the sewage could be held was only 3 feet.

The first accounts of the working of the septic tank which came to this country from England led engineers to believe that its installation meant the end of the sludge problem; that it would maintain itself without any accumulation of sludge. I do not believe that can be shown to be true in any case where a strong domestic sewage is treated.

One difficulty which I have encountered in my efforts to collect information regarding the operation of various plants throughout the country—outside the State of Massachusetts—is the fact that very little detailed information regarding the strength of the sewage, the purification effected by the process, or the amount of sludge accumulated in the septic tank accompanies the reports or statements made respecting the workings of such plants. Statements are much too general, and some uniform system of recording data should be adopted, so that comparisons might be made.

I know that, to a large extent, engineers themselves are not responsible for this lack of detailed information, for municipalities are generally unwilling to grant permission to incur the expenses contingent upon such work. Generally, however, it is money well invested, for one city profits by the experiences of another, and each should do its part in promoting any work relating to the protection of the public health and the improvement of municipal conditions.

Mr. T. Howard Barnes.—I would cite an instance where the experiments made by the Massachusetts State Board of Health have pointed out the possibilities and limitations in the disposal of sewage with sufficient clearness to enable me to plan safely, under conditions differing from those at the place of experimentation.

I would say, in passing, that the boldness required in the case of Gardner or of Brockton, in the early days of Massachusetts filtra-

Chemical House. Press House. Laboratory.

PROVIDENCE PRECIPITATION PLANT, FROM THE WEST.

Providence Precipitation Plant, from the Southeast.

tion systems of sewage disposal, is not now demanded in applying these experimental data to actual works. The splendid demonstrations of the reliability of these data give the force of actual assurance in applying these results to practical ends.

The instance referred to is that of a Southern city, where frost is not troublesome. The sewage would so rapidly reach the outlet as to be perhaps not even stale. The value of the sewage for irrigating purposes was also a factor, especially as it was possible to distribute it by gravity. There existed abundant areas of sand analyzing 155/1000 mm. effective size, and with a uniformity coefficient of 2.15. Having this fineness, the importance of avoiding surface clogging is apparent.

The conditions, briefly stated, then were: (1) A fresh sewage; (2) a filtration area of fine sand; (3) a high average temperature, without freeezing conditions; (4) an easily developed irrigation adjunct.

The value of simple subsidence, as demonstrated in the Lawrence experiments, was the *first* suggestion of particular import. As there demonstrated experimentally, a period of four hours permits rates of filtration of the liquid sewage about double that of sewage simply staled and unscreened. This process had further value in this instance in (1) carrying the sewage to the point of staling or further, and (2) its adaptability to another requirement incidental to all small plants, namely, that the care thereof should be as far as possible automatic. The process of subsidence, therefore, might be accomplished, to a large extent, in the reservoirs needed to detain a quantity of sewage for automatically periodical discharge.

The *second* suggestion deduced from the Massachusetts experiments was the danger of protracting the subsidence and consequent septic action. The experiments made upon Andover sewage showed that a point in septicizing sewage might be reached when toxic elements would be evolved. With a prospective value of the sewage for irrigation, such a consequence would be fatal to the usefulness of it for this purpose, to say nothing of the effect upon the degree of purification obtainable upon the filtration areas.

To meet this point of objection, and to permit a study of the "individuality" of the sewage in its particular surroundings, the receiving reservoirs were designed with compartments capable of being used singly or together. This affords a variable period of detention, also an opportunity to throw one of the subsidence compartments out of commission, while another is being used. A

sludge bed was designed, so situated and connected, that the sludge might be removed to it by gravity. Then, too, an opportunity was afforded for the sludge to undergo septic action, if found desirable, in order to liquefy some portion of the mass.

The works are not yet built, but are cited as an instance, as at first stated, of the great value which the Massachusetts experiments have been in meeting conditions not found in this State.

Mr. Otis F. Clapp.—The city of Providence has adopted the "chemical precipitation method of sewage disposal," the conditions being such that other methods could not be used on account of a want of room within the city limits, and the great expense which would be involved in carrying the sewage to distant points. The subject was thoroughly investigated, and Mr. S. M. Gray, then City Engineer, was sent to Europe to examine the existing systems in use there, his recommendation being for chemical precipitation.

Providence has a population of 181,000, and is situated at the head of Narragansett Bay, 30 miles from the ocean. The shores of this bay are dotted with summer cottages and pleasure resorts, and its waters are used for fishing and the cultivation of oysters and clams. The necessity for removing, so far as possible, any pollution from these waters can be readily seen.

The sewerage system comprises about 190 miles of sewers, about 164 miles being in the regular system and the balance is what is termed the improved or intercepting system; also a sewage pumping station and a precipitation plant. The latter system of sewers, begun in 1890, was so far completed by the spring of 1897 that the pumps were started and the crude sewage emptied at Field's Point.

In 1898 the construction of the precipitation plant was begun, and by September, 1901, continuous treatment of sewage was started, and since January 1, 1902, the full plant has been in operation.

The daily average flow for dry weather is not far from 16,500,000 gallons. This sewage is very strong in the daytime, containing not less, probably, than 6,000,000 to 7,000,000 gallons of wastes from woolen mills, dye works, print works, bleacheries, soap works, jewelry manufactories, etc., which together produce a very dark mass, changeable in color and strongly alkaline.

The chemicals used are lime and sulphate of iron.

The pressed sludge is now being used for filling, although the works are so constructed that the wet sludge can be discharged from the sludge reservoirs into vessels and taken out to sea.

The precipitation plant consists of 20 concrete tanks, 4 large or

Press Room.

Providence Precipitation Plant.

roughing tanks, about 100 feet square, and 16 smaller ones, called finishing tanks, 60 by 115 feet, with 5 sludge reservoirs, a press house, a chemical building and a laboratory and office building.

Eighteen of the tanks are contained in a rectangular area, 270 by 670 feet, with 2 roughing tanks extending to one side, the whole covering an area of 5.03 acres and having a cubic capacity of 11,-133,000 gallons.

The sewage, after passing through a mixing channel, enters the roughing tanks; surface channels are arranged so that the effluent from any roughing tank can be conveyed to any finishing tank through a central channel running lengthwise of the group of tanks; the inlet into the finishing tank is regulated by a gate and a weir across the end of the tank, the outfall being over a weir, which is also the whole width of tank, thus securing an even and steady flow through the tank. When a tank is to be cleaned the clear effluent is drawn off through a floating weir into channels constructed in the masonry walls, and the sludge is discharged through open channels in the corridors, arranged so that the whole length can be inspected and cleaned. The sludge is brought to a sludge well situated close to the press house, from which it flows into the Shone ejectors, situated in a well inside of the house. The ejectors (two 500 gallon) raise the sludge about 50 feet into reservoirs back of the building, thence it flows to the forcing receivers, steel tanks 12 feet long by 8 feet in diameter, to which compressed air of from 60 to 80 pounds pressure is applied and the sludge forced into the presses; the effluent is sent back through the tanks again and the sludge is carried away in steel cars drawn by a small steam locomotive to the dump.

The pumping and pressing is done by compressed air, for which purpose two Rand air compressors are used. These compressors are driven by electric motors, one of 50 and the other of 150 nominal horse power. Electricity for power and lighting the works is furnished by the local electric light plant, and is of the 3-phase type.

The presses were made by John Johnson & Co., of New York; they are the regular English type, with 3-foot square plates, and make ¾-inch cakes.

The character of the sewage, and therefore of the sludge, varies with almost every place, depending mainly upon the number and character of the manufacturing industries existing there.

While it is early yet to give results, not having finished a year of work with the full plant, the appearances look favorable, and give us good reason to believe that we shall not be behind older plants of the same character. Our manager and chief chemist, Mr.

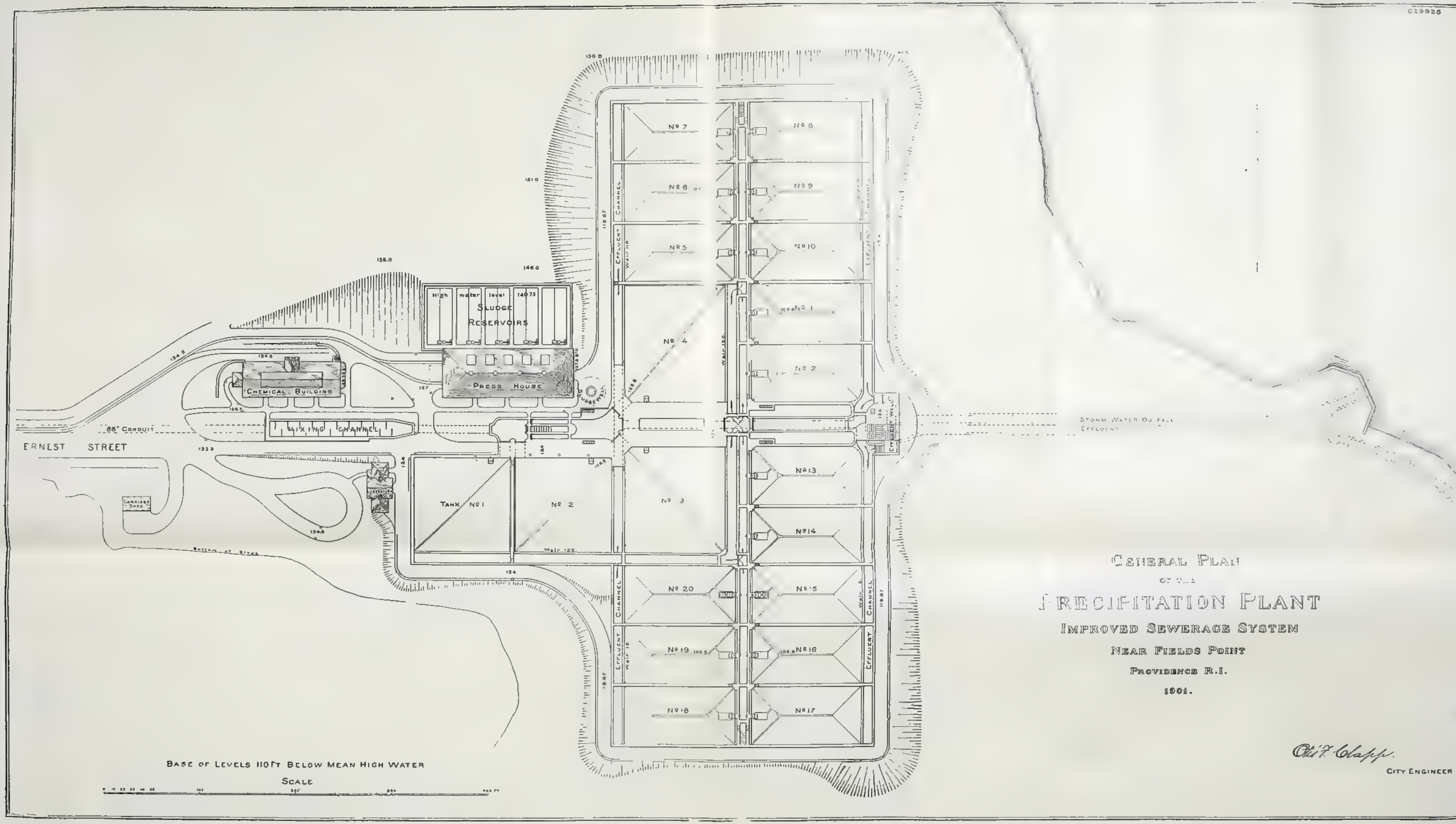
Julius W. Bugbee, had the advantage of 6 years' experience in Worcester, and his work has proved successful from the first.

The cost of the precipitation plant, including everything except original cost of land, has been $309,155.60, and the maintenance will be considerable below the original estimated cost.

The pumping station complete, except land, cost $273,437.24.

Our intercepting sewers have cost $2,967,742.73, and the outlay for land for stations and rights of way has been $141,676, making a total of $3,692,011.57.

The regular system of sewers has cost $3,782,210.43.



General Plan
of the
Precipitation Plant
Improved Sewerage System
Near Fields Point
Providence R.I.
1901.

Otis F. Clapp
City Engineer

THE USE OF THE SEPTIC TANK IN CONNECTION WITH SEWAGE DISPOSAL WORKS.

[Papers and discussion at the meeting of the Sanitary Section of the Boston Society of Civil Engineers held February 3, 1904.*]

By Mr. Frank A. Barbour, Civil Engineer, Boston, Mass.

Any subject is interesting until its merits are settled; and when, on the one hand, it appears that the Massachusetts State Board of Health will not sanction plans involving the use of prolonged sedimentation, and when, on the other hand, we find this feature included as an essential part in a majority of the disposal plants constructed during the past five years and recently recommended by a leading sanitary engineer for use in perhaps the largest sewage purification system yet undertaken in this country, it is apparent that the merits of this process are not yet settled. To add spice to the situation, two different companies have brought suit at a number of places in which claims for proprietary rights are made. Certainly to some of us it has been clearly brought home that the so-called *septic* tank is a live sanitary issue at the present time.

"When is a settling tank not a settling tank?" is an interesting septic conundrum. The answer has been made that the time of holding the sewage is the determining factor, but what this time must be is not yet apparent. It depends upon the strength and age of the sewage, and anywhere from six to twenty-four hours has been set as the optimum period.

With our present knowledge, it is a difficult matter to state when a structure in which the sewage is brought to rest ceases to be a plain settling tank and becomes a so-called septic tank. There is nothing in the design to determine the difference—nothing necessarily in the size, because settling tanks may include provision for mixing and equalizing the flow of manufactural sewage. If the so-called septic tank in contradistinction to a settling tank only exists when the process of liquefaction is a success, then its definition cannot yet be predicated.

Experience has clearly shown that the early claims as to the possible results of liquefaction were exaggerated, and that all tanks into which sewage flows and is brought to such a state of rest that the solids will precipitate will sooner or later accumulate such an amount of sludge as to necessitate emptying. That this is true does not finally condemn the process; it merely limits discussion of its

* Manuscript received March 26, 1904.—Secretary, Ass'n of Eng. Socs.

merits to a consideration of the relative economy and sanitary efficiency of prolonged sedimentation and infrequent discharge of the solid matters, as compared with quick sedimentation, or the application of raw sewage directly to the filters.

It is fair to base the case for these preliminary treatments on their use in connection with some form of filtration—the successful maintenance of which divides itself into two parts—namely, the prevention of clogging of the surface or body of the bed material by suspended solids and the application of the liquid in such doses as to effect purification at the highest possible rates. It is at once apparent that the process of prolonged sedimentation may be likewise considered from two standpoints: first, its effect on the disposition of the solid matters of the sewage; and, secondly, its effect on the liquid portion in making purification possible at higher rates.

Except under the most favorable conditions of soil, it is usually considered to be advisable to remove the suspended matters from the sewage before application to the filters. By whatever method removed these solids are difficult to dispose of, particularly in winter. At Brockton, where the solids are settled out and applied to particular beds, 1850 tons of rakings were handled in 1902, at a cost of about $1500. In winter nothing can be done, and when the thawing process begins with the advent of warm weather the critical period of operation occurs, and there is apt to be considerable odor. It is possible that prolonged sedimentation, even if the tanks require periodic emptying, can be justified in the possibility of holding the solid matters during certain periods of the year. The question is one of relative economy in maintenance and ability to dispose of the staler sludge without nuisance.

At Saratoga, N. Y., there are two periods during which it is especially desirable that the filters be maintained at the point of highest capacity, namely, the summer months, when the population is increased from a normal of 12,000 to about 50,000 by visitors, and the winter, when the temperature falls to an extremely low point. Experience at this plant during the present severe winter has indicated that—aside from whatever liquefaction of the solids may be effected—the ability to avoid the discharge of sludge on the beds during periods of low temperature is of considerable advantage. The time of absorption is much less than in plants handling untreated sewage.

As to the other point of view, from which the process of prolonged sedimentation may be considered, namely, its effect on the liquid portion of the sewage so as to make higher rates of filtration possible, opinions differ. The septic skepticism of the Massachusetts

State Board of Health is largely based on the belief that it is easier to purify fresh sewage than a stale effluent. This, because of the difficulty in effecting nitrification. On the other hand, a prominent engineer recently testified that septic effluent could be purified at rates ten times as great as those possible with untreated sewage, this opinion being based, not so much on the removal of the solids, as on the condition of the organic contents of the effluent.

The speaker believes that by adequate aëration and by application of the liquid to the filters in small doses, and at such rates as to effect good distribution, a stale effluent can be successfully purified.

The anaërobic condition should, so far as possible, be ended before the effluent reaches the filters, and this can be done by properly designed aërators.

In the speaker's experience on six different plants there has been no difficulty in reaching a high degree of purification.

When it comes to comparing the possible rates of filtering stale effluent with those common for untreated sewage, the difficulty lies in the fact that the maximum rates for the latter have not yet been demonstrated. Massachusetts plants are eminently safe and worthy of their reputation, but the distribution systems in use are not so well designed as to reasonably make them a criterion of the maximum rate for untreated sewage. Because rates of 25,000 to 50,000 gallons per acre daily have been the average, is not a proof that higher rates cannot be successfully maintained, and it is very possible that if the same care were taken in the method of dosing, underdraining and general design of filters for fresh sewage as is necessary for the successful handling of a stale effluent, rates more nearly approaching those claimed for the latter would be proved possible.

Within the scope of these remarks but little detailed reference can be made to particular plants, but a few brief statements may be of interest.

In 1899 a tank with a capacity of 140,000 gallons was constructed at Marion, Iowa. It is in one compartment, 63 x 37 x 8 feet, covered with an arched masonry roof. The flow of sewage, as determined by gaugings, equaled about 165,000 gallons daily. This sewage had been emptied into a water course, and suits had been brought against the city by riparian owners. The design included filters, but only the tank was constructed. It was not emptied for more than 2½ years after being put into operation, and has handled the sewage without nuisance and without complaint on the part of those living on the stream. The following analyses of the sewage are taken from a recent paper by Professor Marston:

Total solids	63.20	parts	per	100,000
Free Ammonia	1.60	"	"	100,000
Albuminoid Ammonia	1.80	"	"	100,000

A letter received last week from a city official declares the plant to be an entire success. At all events it has apparently satisfied local conditions.

At the Ohio Soldiers' Home, Sandusky, tanks, in two units of 50,000 gallons capacity each, were put into commission in May, 1903. The sewage amounts to about 100,000 gallons per day, and is somewhat weaker than normal.

Both compartments of the tank were used during the early weeks of operation, but the appearance and odor of the effluent testified to a too prolonged sedimentation, and one unit was thrown out of use. Since the change 62 per cent. of the organic matter of the sewage, as shown by the albuminoid ammonias, has been removed by the tank. The effluent is aërated and automatically applied, in doses of 10,000 gallons, to sand filters. The following figures show analyses of filtrate:

Free Ammonia	0.0052	parts	per	100,000
Nitrates	1.80	"	"	100,000

In June, 1902, tanks of 1,000,000 gallons capacity, in 4 units, were put in operation at Mansfield, Ohio. Each unit is 52 x 92 feet in plan, the depth varying from 6.5 to 7.5 feet, because of a floating orifice, which maintains a practically uniform discharge at all times, and so equalizes the hourly variation in flow. The sewage ranges in quantity from 700,000 to 1,000,000 gallons per day. All four units are used, and the sedimentation period averages somewhat over twenty-four hours.

The sewage is weaker than average town sewage, the free ammonia varying from 1.5 to 2 parts per 100,000. About 55 per cent. of the organic matter, as shown by albuminoid ammonia, is retained by the tanks; on the basis of the suspended solids 75 per cent. is intercepted.

On September 15, 1903, measurements of scum and deposit showed the former to be less than three inches thick at the maximum point, and in many places only a fraction of an inch, while the deposit ranged from three inches to six inches in thickness. Nothing has been removed from the tanks at any time.

The effluent is passed through cinder contact beds, one and one-quarter acres in area, of which one-quarter of an acre is out of commission at all times. The average rate of operating these beds is about 750,000 gallons per acre. The air space has not decreased perceptibly after the first month.

In August, 1903, tanks of 1,000,000 gallons capacity, in four units, each 51.5 x 91.5 x 8 feet deep, were put into operation at Saratoga, N. Y. The discharge of each tank is over a weir and the inlet is governed by a gate, so that the amount received by each unit or the time of sedimentation may be regulated as desired. The amount of sewage handled has varied from 2,000,000 gallons per day in August, to a minimum of 1,200,000 gallons in November, and then up again to 1,800,000 gallons in January.

The sewage was strong in August, when the contributing population varied from 30,000 to 50,000 people, but in the other months it has been weaker than normal. The following analyses of sample collected November 2d, when the flow equaled about 1,200,000 gallons, indicate the quality of the sewage:

Total solids	67.70	parts per 100,000
Suspended solids	28.10	" " 100,000
Free Ammonia	2.1120	" " 100,000
Total Albuminoid Ammonia	0.5200	" " 100,000
Suspended " "	0.3150	" " 100,000
Chlorine	7.94	" " 100,000

Analyses of the tank effluent collected on same day show the following results of prolonged sedimentation:

Reduction of Organic Matter (basis of total Al. Am.)	45.8	per cent.
" " " " " " Susp. " "	70.2	"
" " " " " " " solids	74.7	"

All samples are collected in portions at intervals throughout the day. About 515,000 pounds of dry solid matter has entered the tanks since operation was begun, and 145,000 pounds of these solids have passed out in the effluent. Measurements made on January 23d, with a gauge similar to that shown in Fowler's "Sewage Works Analysis," show the average thickness of scum to be 16 inches and of deposit also 16 inches. The following figures show the character of the scum and deposit:

	Scum per Cent.	Deposit per Cent.
Moisture	86.69	94.24
Volatile matter	10.12	4.49
Mineral residue	3.19	1.27

The specific gravity of the scum is equal to 0.972, and of the deposit 1.024. From the foregoing figures it appears that there are about 200,000 pounds of dry matter now in the tanks, indicating that about 170,000 pounds, or 40 per cent., of the solids left in the tanks by sedimentation have disappeared. The solids which pass through the tanks, while equal to 30 per cent. of the total in the sewage, are so fine and so decomposed that no visible accumulation

takes place on the beds, except just at the outlets, where a slight deposit, which changes from day to day, sometimes appears. Analyses of this deposit show it to contain from 1.3 to 2 per cent. of nitrogen and from 7.4 to 8.9 per cent. of fats.

The effluent is passed over an aërator and applied to sand filters, each 1 acre in area, in doses of 35,000 gallons, at a rate of 8 cubic feet per second. The following results of the dissolved oxygen test may be interesting:

	Per Cent. of Saturation.
Sewage entering tank	4.3
Effluent before aëration	0.0
Effluent immediately after aëration	70.4
Effluent as applied to filters	40.4

No difficulty has been encountered in effecting nitrification, and the percentage of purification, based on free ammonias, has reached as high as 99.8 per cent.

The solids accumulated most rapidly in the tanks during the first month of operation. From September 1st to December 1st conditions were stationary, but after December 1st an increased rate of accumulation has been evident. The temperature has been so low that the surface of the scum in the tanks is frozen.

The foregoing brief references are all to plants too recently put into operation to furnish data of conclusive value, but to the speaker they indicate that there are possibilities in the process of staling sewage which justify its further use.

Opportunity for engineers to scientifically study the operation of plants designed by them is the thing most needed at the present time. Perhaps through the influence of our Sanitary Section such a standard of maintenance will be established that engineers will be retained at least during the first year of operation. If this were done information establishing the optimum period for different qualities of sewage, the most suitable depth and design of tanks and the most economical and sanitary way of handling the sludge when the tanks require emptying might be forthcoming. In the light of present experience, the speaker believes that for small institutional plants, for plants in which it is desirable that the daily attendance be reduced to a minimum for places where sand is difficult to obtain and filters are expensive, in plants where there is relatively much manufactural waste requiring for its purification mixing with the domestic sewage, and in plants where there are seasonal extremes of quantity and quality of the sewage, or of temperature, the process of prolonged sedimentation *is worthy of consideration.*

BY MR. HARRISON P. EDDY, SUPERINTENDENT OF SEWERS, WORCESTER, MASS.

When the septic tank was first introduced in England and it was found that it did not at once fill up with sludge, many engineers forthwith jumped to the conclusion that the magic properties of this method entirely consumed the solid matter removed from the sewage during its passage through the tank. Opinion on this subject, however, is gradually changing as the facts are more carefully studied.

It is now generally acknowledged that there must be an accumulation of solid matter in the tank, and the question which is now paramount is—how much will this amount to? That there is a very active fermentation going on in the tank is obvious to the most casual observer.

The proportion of suspended matter in sewage varies widely, frequently ranging from 25 to 50 per cent. of the total solids. The first function of the tank is that of sedimentation, resulting in removing from 25 to 50 per cent. of this matter. When the tank is first started and there is no old sludge in it the conditions are very favorable to sedimentation. The sewage is admitted in a continuous stream, which is so gauged that it has ample opportunity to spread over the entire width of the basin, and flows through it without creating a current of sufficient velocity to prevent sedimentation.

The solid matter which finds its way to the bottom of the basin at once begins to decompose. It forms a very fertile nutrient medium in which bacteria multiply rapidly. An average of 45 counts gave in the sludge of a septic tank at Worcester over 12,000,000 bacteria per cubic centimeter, while in the supernatant liquid the number averaged at the same time barely 1,000,000 bacteria per cubic centimeter.

The bacteria which live in the sludge are prolific gas producers, and some of the organic suspended matter of the sewage is transformed by them into gases such as carbon dioxide, marsh gas, nitrogen and hydrogen. This process doubtless accounts for some of the loss in organic matter credited to the septic tank.

The gas thus formed is held mechanically in the sludge until it accumulates to such an extent that it is able to lift the solid matter which is holding it down when it rushes to the surface of the water, and if not again held back by solid matter is liberated into the surrounding atmosphere. For evidence of the truth of this last statement there is no need of chemical analysis if the observer has the misfortune to possess a reasonably sensitive olefactory

organ. The gas carries large quantities of sludge to the surface when it is liberated in this way. Some of the gas is even held by the larger particles of solid matter after it has risen to the surface, and it is thus able to float for some time until perhaps a gust of wind or a shower of rain liberates the gas and it again returns to the bottom of the tank, only to be again raised by a fresh lot of gas. If the weather is fair and there is little wind the solids thus brought to the surface may remain there long enough for quite an accumulation of like matter to take place. If this floating sludge, commonly called scum, is not disturbed, it will interweave in such a manner that the elements will not be able to break it up. It will also become partially impervious to the gas generated under it, so that the gases coming up will be retained, and in this way a thick crust will be formed, which will be strong enough for a man to walk upon with perfect safety.

When the fermentation is active in the tank there is a continuous evolution of gas with a consequent stirring up of the sludge. It is this which accounts to a large extent for the suspended matter in the effluent. For this reason it is wise to provide for a distribution of the sludge which will prevent, as far as possible, the carrying over of the solid matter. This was accomplished to some extent with one of the septic tanks at Worcester. The tank had a cement bottom, at a nearly uniform depth, below the top of the basin throughout its length. Wooden partitions were erected across the basin laterally, dividing it into 4 compartments. These partitions were only just high enough to prevent the sludge from flowing from one compartment into the next. Directly over these partitions were hung wooden partitions extending down from the surface of the water, when the basin was full, to a depth sufficient to prevent the scum from passing from one section to the next. In this way the sludge, when it first comes into the tank, is confined largely to the first section. Practically all of the heavier particles are retained here. The most active fermentation is in this section, and as the sludge is lifted by the gases and the smaller particles fall slowly to the bottom they are taken over into the next section by the current. In this way there is a sort of separating of the different qualities of sludge, and that which is less actively engaged in fermentation is carried down toward the discharge end of the tank. This greatly facilitates the removal of the suspended matter. The scum is also largely held in the first section by the top partitions. The details of this arrangement of partitions are given only to illustrate the

theory. They were temporary in nature and only for experimental purposes.

The experiments just alluded to have been conducted during about 4 years. The tank is 166.66 feet long, 40 feet wide and about 7 feet deep. Its capacity when in operation is 350,000 gallons, allowing for filling once in 24 hours. From June, 1902, until July, 1903, it was in continuous operation at rates ranging from 300,000 gallons to 750,000 gallons per day. Storm water was always excluded. In all, approximately 185,000,000 gallons were passed through the tank in that time. The amount of sludge removed from the tank at the end of the period was 56,250 gallons, containing 65,325 pounds of solid matter. The suspended solids entering the tank, but not passing out with the effluent, amounted to 134,904 pounds. Deducting the solid matter removed from the tank in the form of sludge there were 69,579 pounds of solid matter destroyed. This amounts to 51.65 per cent. of the suspended solids removed from the sewage.

The amount of sludge removed from the basin at the end of this period came to 1.5 cubic yards per 1,000,000 gallons of sewage passed through the tank. This is less than one-half the amount obtained from another experiment, and it is very doubtful if it would be safe to figure on an accumulation so small. It is also doubtful just how far to allow the sludge to acccumulate in the tank on account of the increasing amount of suspended matter carried out with the effluent. If we allow 3 cubic yards per 1,000,000 gallons of sewage, the amount of sludge which would have been produced at Worcester in 1903, had the entire flow of sewage been treated by the septic process, would be 17,028 cubic yards, not exactly in a negligible quantity.

The sludge from the septic tank is a very characteristic material. It is black, usually finely divided, rather heavy and of an extremely offensive odor, unless it has been allowed to undergo very complete decomposition. To run it out onto land in its natural wet condition would make an intolerable nuisance if there were any dwellings nearby or if the plant was near a frequented road. It can be reduced in volume by filter pressing only with great difficulty and at very excessive cost.

After all, even this process has not gotten rid of the sludge, which has always been the cause of serious perplexity with all systems of sewage disposal—sedimentation, chemical precipitation and filtration in all of its different modifications.

BY MR. GEORGE E. BOLLING, CHEMIST, BROCKTON SEWER DEPARTMENT.

At Brockton we conducted a septic-tank experiment during the months of August and September in 1900.

We calculated that the lighter portion of our sewage, which amounts to about 90 per cent. by volume, was being disposed of quite satisfactorily on the intermittent filtration beds, but the other 10 per cent. by volume contains the settlings from the bottom of the receiving reservoir, and the practice has been to discharge this sludge on certain beds set apart for the purpose, each bed receiving a dose every fourth day. The very rapid clogging of the surface, and the expense of cleaning these beds, induced the Commissioners to construct a small experimental septic tank, in order to obtain more light on the subject.

In August, 1900, the solids of the sludge in parts per 100,000 were 294, and about 4 doses could be applied to a bed before clogging it, and a dose of say 90,000 gallons would remain upon the bed 2 days before absorption.

Our experimental tank was patterned after the original septic tank at Exeter, in having a submerged inlet and outlet, and the sewage passing through it being kept at a constant level. The tank was made of wood, 10 feet long, 3 feet wide and about 6 feet deep, lined with galvanized iron, and was of about 1100 gallons capacity. Owing to the sewage flow at the beds not being continuous a storage tank was also provided, from which a uniform flow of sludge was delivered into the septic tank by means of a movable outlet controlled by a float. The results obtained from its use as an open septic tank for the period of 2 months, the time of passage through the tank being 24 hours, are given in the table on opposite page.

AVERAGES BY MONTHS OF ANALYSES OF SLUDGE ENTERING AND OF EFFLUENT ISSUING FROM SEPTIC TANK.

(Parts per 100,000.)

		RESIDUE ON EVAPORATION.						AMMONIA.				CHLORINE.	OXYGEN CONSUMED.	
		TOTAL RESIDUE.			LOSS ON IGNITION.			FREE.	ALBUMINOID.					
		Total.	Dissolved.	Suspended.	Total.	Dissolved.	Suspended.		Total.	Dissolved.	Suspended.		Filtered.	Unfiltered.
FIRST MONTH.	Sludge	294.45	45.17	249.28	208.07	20.17	187.90	3.2220	4.9262	0.4479	4.4783	10.15	6.75	38.27
	Effluent	68.90	52.22	16.68	37.86	24.72	13.14	4.3000	0.8154	0.5250	0.2904	10.37	6.19	11.55
	Decrease, per cent.	76.60	. . .	93.31	81.32	. . .	93.01	. . .	83.45	. . .	93.51	. . .	8.29	69.82
	Increase, per cent.	. . .	15.61	. . .	. . .	22.56	. . .	33.46	. . .	17.21				
SECOND MONTH.	Sludge	279.28	55.28	224.00	199.82	25.52	174.30	5.1645	5.3569	0.4750	4.8819	11.98	8.14	40.83
	Effluent	77.20	64.52	12.68	42.25	32.28	9.97	6.4075	1.0187	0.6031	0.4156	12.10	6.88	12.84
	Decrease, per cent.	72.36	. . .	94.34	78.86	. . .	94.28	. . .	80.98	. . .	91.49	. . .	15.48	68.55
	Increase, per cent.	. . .	16.71	. . .	. . .	26.49	. . .	24.07	. . .	26.97				

After 2 weeks' use there was a deposit of 7 inches in the bottom of the tank, and a floating mat of scum 11 inches thick at the inlet end and ½-inch thick at the further end. A brace across the center of the tank, which apparently prevented the scum forming as quickly at the further end, was removed at this time.

At the end of 4 weeks' use the deposit amounted to 8 inches in depth, and the scum was 20 inches thick at the inlet and 6 inches thick at the outlet end.

After 8 weeks' use the deposit was still only 8 inches in depth, while the scum was 30 inches thick at the inlet and 20 inches thick at the outlet end, and tended to clog the slotted outlet pipe.

The tank was then cleaned out and the outlet pipe was to have been lowered and the trial continued, but at this time the Commissioners figured up the cost of cleaning out the tank, and judged that if a sufficiently large tank was constructed to treat all our sludge by the septic method, the cost would be greater than the present system of raking the beds, and decided that the experiment be discontinued.

From the analyses it appeared that during the 8 weeks' period of operation there entered the tank 1345.21 pounds of solids in suspension. Of this amount:

602.39 pounds,	or 44.78 per cent.,	removed on cleaning.
218.33 "	" 16.23 "	went into solution.
83.45 "	" 6.20 "	suspended in effluent.
441.05 "	" 32.79 "	escaped as gas, or is otherwise unaccounted for.

The solids removed from the tank on cleaning presented the following composition:

	Scum.	Deposit.
Water	86.74 per cent.	92.49 per cent.
Organic Matter	9.38 "	5.55 "
Mineral "	3.88 "	1.96 "
	100.00 "	100.00 "

The specific gravity of the scum was 0.988, and of the deposit 1.032. After the pile of material taken from the tank had been exposed for a week an analysis, made to determine its value as a fertilizer, figured up between $3 and $4 a ton. It contained nitrogen to the amount of 1.96 per cent.

It was a matter of regret that the experiments were not carried further, so as to watch the effects of varying rates of flow through the tank and to obtain some data concerning filtration of the septic effluent. Our experiment was not carried into the winter, but was conducted at a time most favorable to the operation of the septic tank. The experiment was short, but impressed us that sludge alone was too stiff a proposition for the septic tank to deal with.

BY MR. ANDREW J. GAVETT, PLAINFIELD, N. J.

The city of Plainfield, with a population of about 18,000, is situated 24 miles from New York City. A sewerage system was constructed by the city in 1895, separate sewers being used for storm water and for sewage. The sewage was originally discharged on intermittent sand filters; but, in 1901, septic tanks and contact beds were constructed, and since that time the sewage has been treated by the new works. There are now 1775 sewer connections, 275 having been added during the past year, and the flow of sewage has nearly doubled since the new purification works were started, being now about 800,000 gallons per day, which increases to over 1,000,000 gallons at times of high-ground water. It is proposed to examine and repair some of the sewers in the wet district as soon as the weather will permit, and plans for enlarging the disposal plant are also under consideration.

The disposal plant consists of 2 septic tanks, side by side, under one roof, and a double set of bacterial contact beds, 8 in all; the new works are located 200 feet from the nearest streets, and the sewage does not appear on the surface until discharged into the brook.

The septic tanks are each about 50 by 100 feet and 7 feet deep, the water rising 6 feet above the bottom. They contain about 450,000 gallons of sewage, and with the average flow the sewage is 13 hours in passing through the tanks. After leaving the tanks the effluent passes over a weir in a thin sheet and falls into a channel, the weir and channel extending the full length of each tank, 100 feet in all.

The contact beds are in 2 sets of 4 each, the first set being 5.42 feet higher than the second, each bed having an area of 9750 square feet and a total depth of 5 feet. In the upper set of beds the working material is trap rock, 3½ feet deep, varying in size from ¼ to 1½ inches, and in the lower set slag is used in some beds and cinders in others, somewhat smaller in size than the stone in the upper beds. The bottom 6 inches and the top 12 inches of all the beds are composed of 2½-inch stone; in the former are the horseshoe drain tiles and in the top foot of the material (into which the sewage is not allowed to rise) distributing pipes are laid, consisting of vitrified sewer pipes from 3 to 12 inches in diameter, laid with open joints, except the 12-inch pipes, which are cemented. The partially purified sewage passes continuously from the septic tank to a gate chamber at the intersection of the division walls of the first or upper contact beds. Here it is diverted by wooden gates to each of the 4 beds in succession. After flowing into one bed for 2 hours the sewage is

turned to the next bed, each of the 4 receiving the flow in turn. The sewage in the first bed, after being retained for 2 hours, is drawn off, and passes through a pipe to the gate chamber of the second set of contact beds, where the same process is repeated. After the period of rest in the second set of beds, the effluent is turned into the brook. Each bed receives a rest of 2 hours before each filling, and 2 hours each are allowed for filling and for emptying; the material in the beds is sufficiently coarse to allow the air to be drawn down to the bottom of the beds at each emptying.

The sludge accumulates very slowly on the bottom of the tanks, but the scum gathers more rapidly, and is removed, about three times a year, through the sludge pipes to a sand filter bed, after as much as possible of the clearer middle water has been run off onto other beds, separate valves and pipes being provided for this purpose. When the sludge is running from the tanks a deodorant is added, either strong limewater or permanganate of potash, the latter being preferred.

During one period of 5 months, including winter weather, the scum increased about 1.25 feet, making, in both tanks, 463 cubic yards; after this was sufficiently dried to be piled up it measured 130 cubic yards. In the following warmer 5 months the scum amounted to about 1 foot in average depth. These figures are only a rough approximation, as it is difficult to measure the varying thickness of scum in the septic tanks. The flow of sewage during this time was about 650,000 gallons per day, this quantity being at times much increased by ground water.

The sludge is allowed to dry out on the sand beds and is used as a fertilizer on them and on other parts of the property, on which good crops of sweet and yellow corn are raised.

The temperature of the sewage and effluent is nearly constant; recently, when the temperature of the air was 10° below zero, that of the sewage was 56°, the effluent from the septic tank 55° and the final effluent 53°. Since then, during a time of much ground water, the temperature of the final effluent fell to 49°, but afterward returned to the normal temperature.

The effluent from the works has been satisfactory, and there have been no complaints from the adjoining owners or residents since the present works were installed. The New Jersey State Sewerage Commission, in its report written in 1902, states that "87 per cent. of the bacteria were removed and the putrescible matter completely disappeared."

Analyses in the spring of 1903, by Mr. L. R. Thurlow, Health Officer of the Plainfield Board of Health, gave the bacterial

efficiency of the septic tanks as 55 per cent., and of the whole plant as 87 per cent.; the efficiency of the septic tanks, as shown by the removal of albuminoid ammonia, was 38 per cent., and by oxygen consumed 44 per cent. Mr. Thurlow gives the efficiency of the whole plant as 90 per cent. by the removal of albuminoid ammonia, and 86 per cent. by oxygen consumed. He believes that the plant is doing better work now.

The works are operated by hand, requiring the services of 1 day man and 1 night man, who are paid $67.50 and $45 per month, respectively; additional labor costs about $15 per month.

The cost of the plant, exclusive of land and engineering services, was $38,750.

BY MR. R. WINTHROP PRATT, ENGINEER, OHIO STATE BOARD OF HEALTH.

In most localities in the State of Ohio the geological conditions are such that no sand or gravel, suitable for sewage purification, can be obtained without transporting it over long distances, making the cost prohibitive.

To these conditions is largely due the fact that, since about the year 1897, when the septic tank began to be so much in evidence, nearly every proposed sewage purification scheme has included a septic tank as a means for reducing the area of necessary filtering material. The Ohio State Board of Health has in some cases approved these plans just as they were submitted, and, in other cases, where a high degree of purification was necessary, has required the addition of a certain amount of filtering material in order not to place too much dependence upon favorable action in the septic tank.

There are now in use in this State, by cities, villages and public institutions, 26 sewage purification works, while 18 more will probably be in use in the near future. Of the 26 plants now in use 5 cities and villages, 3 public institutions and 1 manufacturing establishment use the septic tank; and of the 18 cities and villages having proposed plans 14 will use it.

Nearly all of the systems now in use have a storage or flush tank of some kind, in which more or less septic action occurs, but those here mentioned are all designed strictly as septic tanks, and their construction permits of obtaining full benefit, according to theory, from whatever favorable bacteriological action may take place in them.

In no cases are sufficient chemical and bacteriological data available to accurately judge of the efficiency of these tanks, but they have all been inspected from time to time, and a few chemical

samples have been taken. As far as can be learned, the tanks continue in use for from 1 to 2 years without decreasing more than 25 per cent. in capacity. The "matte" formed on the surface varies from nothing to 1 foot in thickness. Both surface and bottom accumulations appear to remain fairly constant in volume in each case as long as the conditions of operation remain the same.

The odor from the tanks is often no more objectionable, if as much so, than that from the average settling tank; but in some cases very offensive odors are created.

We have then little uniformity in the degree of usefulness of the septic tank, and this strongly emphasizes the fact that not only should all conditions be carefully studied and made as favorable as possible before designing a tank, but that after the tank is in use it should be carefully watched and tested, in order to determine the most efficient mode of operation.

THE EAST CLEVELAND TANK.

East Cleveland is a residential suburb of the city of Cleveland, having a separate local government. The population has increased from 1000 in 1895 to 6000 at the present time. In 1898 and 1899 a separate system of sewerage was built and designed to drain nearly the whole town. The domestic sewers are provided with underdrains, but, nevertheless, there is at times a large amount of leakage into them; this leakage is probably increased on account of the storm sewers being laid above the domestic sewers. There are now 40 miles of domestic sewers which receive the sewage of over 5000 people, but no manufacturing wastes. The dry-weather flow is from 300,000 to 400,000 gallons per day, but increases to more than 1,000,000 gallons in wet weather.

A system of sewage purification was installed in 1899 according to the plans of the City Wastes Disposal Company, of New York, which plans provided for the continuous filtration of the sewage; first, downward through egg-sized slag; second, upward through similar material; and third, downward through "aërators" or filters of small-sized "pea" coke. All filters receive continuous forced aëration furnished from a blower in the pumping station. The rate of application to the first filter was 10,000,000 gallons per acre per day, and the rate through the entire area of filtering material was 660,000 gallons per acre per day.

This system was used for about 2 years, but it was found that the filtering material needed frequent cleaning at great expense, due, it is said, to the increase in the volume of sewage and to the clay and other irreducible matter reaching the works in wet weather.

Therefore, late in 1901, the plant was increased along the same lines, and in addition a septic tank was built for preliminary treatment of the sewage. This tank is of brick masonry, 24 x 87 feet and 11 feet deep. It is covered by a wooden pitched roof, the top of which is 9 feet above the level of the sewage. Sewage enters at mid-depth through openings, 6 inches square, equally spaced across one end, and is drawn off through horizontal slots, 12 inches by 2 inches, equally spaced across the other end. The tank holds 170,000 gallons, or 10 hours' ordinary flow. The horizontal velocity is 1.8 inches per minute.

After one year's use the tank was said to contain a scum less than 2 inches thick, while the solid matter at the bottom was 2 feet deep. It has now been used about 1 year since cleaning, and contains about the same amount of material as at the end of the first year.

Chemical analyses of composite samples collected by the attendant in April, 1903, show no marked changes in the composition of the sewage during its passage through the tank.

However, since the enlargement of the works and the introduction of this tank, it has been necessary to wash the filtering material less frequently, and the effluent from the works is clear and odorless and produces no nuisance. A few chemical analyses have been made of this effluent, which show it to be well purified.

The odor from the septic sewage, as it flows onto the filters, combined with the odor from the clogged filtering material, is offensive, and causes more or less complaint on the part of the nearest residents.

The cost of the tank was about $3000, while that of the entire plant was $66,000. The annual cost of maintenance is $3000.

THE KENTON TANK.

The system of sewage purification at Kenton, also designed by the City Wastes Disposal Co., is septic treatment, followed by intermittent filtration through "pea" coke covered by broken stone.

Though Kenton has a population of 8000, the sewage of only 400 people is conveyed to the purification works. The daily flow is about 25,000 gallons, all of which is domestic sewage, except the surface water which is admitted through 2 catch basins.

The septic tank is 28 feet long, 16 feet wide and 6 feet deep, holds 21,000 gallons and is covered by a wooden house. Sewage first passes through a small grit chamber and then enters the tank 2 feet below the surface and is drawn off through small openings, at the other end, at the same depth. It then enters one of the 3

"dosing" filters, which are flush tanks, filled with broken stone, and which discharge intermittently onto the filter beds.

These beds consist of 3 parallel open tanks, each 10 x 100 feet, and filled with a layer of "pea" coke 18 inches deep at the upper end and 4 inches deep at the lower end. The coke is covered with broken stone. The beds have a sharp slope away from the septic tank, so that each dose of sewage flows through them laterally with a kind of wave motion; the idea being to obtain as much aëration as possible and at the same time keep the sewage from appearing on the surface of the filters.

The septic tank is divided longitudinally, so that one-half can be used. The whole tank, however, has been in use ever since the plant was first operated in June, 1902, thus making the septic period from 20 to 24 hours. There was, after 15 months of operation, about 1 foot of sludge in the bottom of the tank and no scum whatever on the surface. However, when storm water is brought in by the sewers a scum quickly forms, but soon disappears when the flow of storm water ceases. It has not yet been necessary to clean the tanks.

Very little odor can be noticed around the plant, and I found, upon entering the house over the tank, after it had been locked for several weeks, that the odor inside was not in the least offensive; in fact, it was much less than that arising from any settling tank that I can recall.

There is no doubt that the tank is successful as a sludge destroyer, but the subsequent treatment has not yet been studied sufficiently by the writer to justify a definite statement as to its efficiency.

THE MANSFIELD TANK.

The largest system of septic tanks and contact beds in the State of Ohio is located at Mansfield, and has been in operation about 2 years.

Mansfield has a population of about 20,000, but only about 9000 are connected with the sewers. A considerable portion of the sewers were built some years ago and received much surface and ground water. An overflow, however, is placed in the trunk line, so that not more than 1,000,000 gallons per day can reach the purification works, and this is the average amount treated. As would be expected, sewage under these conditions is quite weak. The main sewer discharges into a grit chamber at the pumping station, where the sewage is screened and pumped continuously to the septic

tanks, from which it is drawn off at a point about 3 feet below the surface.

There are 4 tanks, having a total capacity of 1,000,000 gallons, or about 24 hours' flow, and all 4 are used. By means of floating orifices the discharge from the tanks is kept constant, regardless of the flow into them. This may cause a daily fluctuation in the surface of the liquid in the tanks of about 6 inches.

Aëration of the septic effluent is obtained: first, by its drop into a collecting channel; and, second, by its passage over aërating steps.

The aërated sewage is then applied through automatic apparatus to contact beds, 5 in number, each $\frac{1}{4}$ acre in area; and the effluent from these beds is discharged into a small stream.

The plant is well removed from any dwellings, and the septic tank is ventilated into the stack at the pumping station. There is no objectionable odor around the plant. One of the tanks, after $1\frac{1}{2}$ years' use, was drawn off and only a few inches of deposit found in the bottom. No surface scum has formed to any extent in any of these tanks.

The final effluent appears clear and odorless, and tests have shown that the entire process removes from 80 to 90 per cent. of the organic matter, as shown by the albuminoid ammonia and oxygen consumed, and from 98 to 99 per cent. of the bacteria.

This plant, as well as the ones at Trumbull County Infirmary and Soldiers' Home at Sandusky, was designed by Snow & Barbour, of Boston.

THE TANK AT SOLDIERS' AND SAILORS' HOME, SANDUSKY.

The population of this institution is 1400 to 1500, and the quantity of sewage is about 100,000 gallons per day. The sewage is strong.

There are 2 septic tanks, each 26 x 40 feet and 7 feet deep; either one or both can be used. When 1 only is used sewage remains in the tank 12 hours, and when 2 are used it remains 24 hours.

After passing through a grit chamber and screen the sewage enters the tank 3 feet below the surface and leaves at the same depth at the other end. It is then aërated by passing through about 100 feet of galvanized iron gutter about 2 inches deep, from which it overflows in thin streams or sheets and is conveyed into a flush tank.

The flush tank discharges automatically upon intermittent sand filtration beds about $1\frac{1}{4}$ acres in extent. The sand used in these

beds is about 4 feet deep and of very favorable size and quality for sewage purification.

The tank has been in operation some 8 or 9 months. A heavy scum of a foot or more has formed at the surface and there is more or less of a deposit at the bottom. The tanks have not been cleaned, however. At the beginning both tanks were used, but the septic effluent proved to be so offensive that it was objectionable to the occupants of houses 600 to 1000 feet distant. One of the tanks, therefore, was cut out of service, and since then the odor of the septic sewage has been less objectionable.

The septic tank effluent contains much finely divided matter, which is deposited in the aërating gutters, and has to be removed frequently. Originally a strainer of broken stone was used before the sewage entered the flush tank, but this strainer became so quickly clogged that its use has been discontinued.

The final effluent from the sand filters has been well nitrified and of very satisfactory character.

TANK AT TRUMBULL COUNTY INFIRMARY, NEAR WARREN.

This institution has a population of about 100. The sewage is purified by septic tank and intermittent filtration through coke. The tank is 15 feet long, 5 feet wide and 5 feet deep, and holds 3000 gallons, or a little more than 1 day's flow. There is no screen of any kind at entrance to the tank. The sewage enters and leaves a short distance below the surface. The tank effluent, after passing over aërating steps, is collected in a reservoir of 4000 gallons capacity, from which it is pumped daily to the coke beds.

These beds contain 4½ feet of fine coke, and the average amount of sewage treated by them is 60,000 gallons per acre per day, applied daily, in doses of 2500 gallons, lasting about 1 hour. The effluent appears in the underdrains in about 30 minutes after the sewage is applied. It is clear and odorless, and analyses have shown it to be well purified.

The sewage of this institution is unusually dilute, due to leakage, which at times is so great as to necessitate the discharge of raw sewage directly into a small stream.

During its 4½ years of operation this septic tank has been cleaned but once. The sludge in the bottom retains a constant depth of about 1 foot and the scum is 3 or 4 inches thick. The long septic period and subsequent storage in the reservoir does not seem to prevent satisfactory purification.

The odor is very strong, but is largely confined to the small wooden pump house over the tanks, which is ventilated into the

stack at the boiler house. The iron of the pump has been attacked by gases from the tank. This system of ventilation, however, enables the tank to be located near the institution buildings without causing a nuisance.

OTHER TANKS.

The shops of the Lake Shore and Michigan Southern Railroad employ 500 hands, and are located in the center of the village of Collinwood.

A system of sewage purification, consisting of septic tank and coke contact beds, was constructed in 1902. Both tank and contact beds are covered, although trapdoors are placed over the latter and are usually kept open. No definite information is available any more than to say that it apparently purifies the sewage well enough to avoid polluting the small stream into which the effluent is discharged, and that no objectionable odors are complained of either by the employees of the shops or by occupants of houses a few hundred feet distant. It is understood that no cleaning of either tank or contact beds has been necessary during its 18 months or more of service.

Tanks are also now in operation at Delaware and Westerville, but at these places the works have been in but a short time and accommodate only a few hundred people.

It may be mentioned in closing that the city of Columbus contemplates making experiments on the septic tank and other methods of sewage purification on a larger scale than has ever before been done. The results of these experiments, if made, in addition to helping solve the sewage disposal problem at Columbus, will be of great value and interest to engineers and sanitarians in general.

BY MR. X. H. GOODNOUGH, CHIEF ENGINEER, MASSACHUSETTS STATE BOARD OF HEALTH.

The septic tank, as so described, was first used at Exeter, England, and the results of its early operation were given to the public about 7 years ago.

The results of the early operation of this tank appeared to show that, by allowing sewage to flow slowly through a closed tank, kept full at all times, for a period of from 24 to 36 hours, the solid matters in the sewage became liquefied, and either went into solution or remained in suspension in an extremely finely divided state. It also appeared that much organic matter went off in the form of gas, and that very little solid matter or sludge accumulated in the

tank. By the use of this tank it appeared at first that the sludge problem was practically eliminated, and the sewage remaining was weaker than the original in organic matter, contained little or no coarse matter in suspension, and could be purified more rapidly than ordinary sewage by subsequent filtration.

The announcement of the results of the operation of this tank at Exeter created widespread interest, and with the announcement of the results of experiments upon certain forms of rapid filtration of sewage, which appeared at about the same time, greatly stimulated the investigation of methods of sewage purification.

The septic tank was not claimed, by those who first employed it, to be, by itself, a means of sewage purification. It is a preliminary process, which it was claimed could be advantageously employed in connection with sewage purification works. It is essential to keep this in mind, since, even at the present day, the septic tank is sometimes considered to be by itself a complete means of purifying sewage.

It is not my intention to refer, except in a general way, to the experiments made at Lawrence by the State Board of Health, which have been carried on under the direction of Mr. Clark, who will present a summary of these results; but attention having been called to the fact that the septic tank has not been employed to any considerable extent in connection with sewage disposal works in Massachusetts, some of the reasons why its use has not become more general may be of interest. Only 1 septic tank has been used in connection with the sewage disposal works of any city or town in Massachusetts, and the use of this tank as a septic tank has been abandoned. There are several reasons why the use of the septic tank has not become more general here, since many works using this process have been constructed in other States and in Europe.

When the results of the operation of the Exeter tank were first announced it was obviously necessary, before using this device in practice, to first test its operation under the conditions existing in this country, and with this object experiments upon the operation of septic tanks were begun at Lawrence. The results of these experiments and of experience elsewhere soon gave evidence that there was a great variation in the results obtained from this method of treating sewage in different places and at different times, and that there were some other troublesome features connected with this form of treatment.

In some cases the results were very similar to those first announced at Exeter; in others, the results were unsatisfactory, and the sewage was brought into such a condition, after passing through

the tank, that it was difficult to purify it satisfactorily by a subsequent filtration. Moreover, experience in the operation of septic tanks showed that in many cases sludge accumulated within them more or less rapidly and that the sludge problem was not eliminated. Sludge from such tanks, moreover, has been found far more offensive in some cases than that from ordinary settling tanks. The fact was discovered that sewage was in many cases rendered extremely offensive after passing through a septic tank,—a condition which it is very desirable to avoid at a sewage disposal works.

There is no sure way of determining beforehand what results can be obtained in the treatment of the sewage of a given town by means of the septic tank—showing the great importance, before using this method of treating sewage, of making adequate investigation by means of experiments to determine the results that are likely to follow its use.

There are other important reasons also why the septic tank has not come into general use in this State.

The early investigations upon the purification of sewage by intermittent filtration showed that a well-purified effluent could be obtained by filtering sewage through sand at rates ranging in some cases as high as 100,000 gallons per acre per day and an excellent effluent produced, and the results of experience in the operation of numerous sewage purification works built on the lines indicated by these investigations have shown at many places during a period of many years that well-purified effluents can be obtained with sewage from any of our cities and towns by following the experience furnished by the early experiments at Lawrence and the actual operation of these works.

The experiments upon the purification of septic tank effluents have not given such favorable results as are obtained in actual practice by intermittent filtration. Areas of sand and gravel well adapted for the purification of sewage by intermittent filtration are generally easily available in this State, and the cost of the preparation of sufficient areas for the purification of sewage by intermittent filtration is not generally so large as to make it important to attempt to reduce the cost of the works by the employment of the septic tank. In nearly all, if not all, the cases in which sewage purification works have been constructed in this State, the cost of installation and operation has probably been less than it would have been had a preliminary treatment by the septic tank been employed, while the resulting effluent is probably of better quality than would have been obtained by the use of the septic tank.

Under these circumstances the use of the septic tank has not

become extensive. It may be added that in the only case in which the septic tank has been employed on a comparatively large scale in connection with the works for purifying the sewage of a city or town, sludge accumulated rapidly in the tank. During much of the time when this tank was operated as a septic tank the sewage was diverted into the river and the operation of this septic tank was a failure. The tank is, however, a useful adjunct to the works as a storage reservoir for the night flow of sewage.

The principal experiment by the State Board of Health upon the use of the septic tank—that at Andover—has also given unsatisfactory results in several important respects, chief of which is the fact that the effluent from this tank has not been purified efficiently by subsequent filtration.

So far as the experience in this State goes, then the principal experiment upon the use of a septic tank at Andover has given unsatisfactory results, and as the only case in which the septic tank has been actually employed for the disposal of sewage it was a distinct failure.

While the septic tank has not been a success, as operated in this State, its possibilities do not as yet appear to have been exhausted, and it may be that, in connection with some kinds of sewage, especially those greatly affected by manufacturing waste, its use may be found of advantage.

The septic tank was patented by those who first employed it at Exeter, and other patents upon sewage disposal claim to cover it in this country. Much misunderstanding exists as to the nature of the process and the methods of producing septic action, and it would probably be difficult to determine in some cases whether a given tank is a septic tank or not. In some cases towns and corporations have already paid small royalties to persons claiming patents covering tanks of various kinds employed at sewage disposal works, and claims have been entered in cases of other works where it would seem that by no stretch of its present definition could the tank used be called a septic tank. In some cases these settlements have been deemed good business, since the amount asked for has been much less than would be necessary to contest the case in court; but in at least one case, I am informed, a local authority which had settled with one such claimant for a small sum has already been confronted with the claim of another. Some of these cases are actually already on trial, so that it is likely that before very long something more definite may be known as to the court's opinion of these claims. The claimants of septic tank patents have even entered claims for royal-

ties from places having sewage reservoirs used for the storage of the night flow of sewage in order to avoid pumping at night; but these claims have not thus far been pressed in the courts.

BY DR. DOUGLAS C. MORIARTA, SARATOGA SPRINGS, N. Y.

I came here to-night, Mr. Chairman, to listen and learn all about septic tanks, and not to discuss them. My practical experience with them is *nil*. I can, however, with your indulgence, give you my experience with a sewage disposal system which involves a retention tank; though if I were to confine my remarks to discussing the septic tank *per se* I would be able to say but little.

Our proposition at Saratoga was a peculiar one, in that the sewers received storm water and surface water, which of necessity had to be separated from the sewage. This has been accomplished, and the sewage now runs by gravity to a pumping station, and is there raised into several retention tanks. Here the sewage remains for several hours, when it passes into an aërator, then into the dosing tanks and onto the filter beds.

The results of this treatment, from our standpoint, have been very satisfactory; that is, we have no objectionable odor, and the effluent after leaving the contact beds is satisfactory to the State Board of Health. The quantity of sewage that we care for daily is approximately 2,000,000 gallons. As I have said, the sewage runs into the large tank and from there into the aërator. In this apparatus it comes up from the center like a fountain, and is spread out into a thin sheet on a disk of iron, having a conformation not unlike an umbrella opened. After being aërated, it goes to the dosing tank, which has a capacity of 50,000 gallons. This tank is provided with an automatic apparatus, which can be so adjusted as to discharge its contents on four different beds consecutively.

Concerning the value of the sedimentation or retention in the tanks, I hardly know what to say after listening to the remarks of your experts on this subject; because our plant has only been in operation since July, and thus far we have had no occasion to empty it, nor are we annoyed in any way from it, and our chemist informs us that we are having a marked liquefaction of the sludge. At the aërator there is a slight odor, but not at all marked, and when the sewage is on the beds it is even less. In the immediate neighborhood are two residences; thus far we have had no complaints. If we ever have to empty our retention tanks and it acts as those described by the authors of your interesting papers, we will probably have something to say on this subject when we meet again.

A feature which may be of interest is the operation of our filter beds during the present cold winter. We have never experienced a winter in our locality that has been as cold as this within ten or twelve degrees. The beds were nicely iced over and have worked finely. For a time the size of the doses on the beds was increased to 100,000 gallons; the additional heat in this quantity of sewage was sufficient to operate the beds without difficulty.

As I have said, the effluent is satisfactory to the State Board of Health, so we have had no trouble in that particular way.

Another feature in the minds of the Commission is the attractiveness of our plant; this is in a measure due to the arrangement of the beds, their location and their grading and care. Our disposal plant is really quite a point of interest in our village.

We have twenty-one beds, and of these two are prepared for sludge. So far it has only required two or three men and one horse to care for them, which is much less than we anticipated.

BY MR. HARRY W. CLARK, CHEMIST, MASSACHUSETTS STATE BOARD OF HEALTH.

I can add very little to this septic tank discussion other than a recapitulation of the Lawrence Experimental Station work.

The problem is one that many of us have been trying to solve during the past 6 or 7 years, and a great variety of opinion in regard to the value or the utility of septic tanks is expressed by different investigators along this line, and widely different results appear to have been given by septic tanks at different places. I suppose there is no doubt, if we read correctly the current English sanitary journals, that, while all that was claimed for the septic tank at first is not now believed in, yet the majority of English sewage experts still believe that a septic tank is a valuable adjunct to most filtration plants. Anything that will aid in decreasing the area necessary for filtration appeals to them strongly, this being so, I presume, on account of the scarcity of cheap sandy land, the cost of construction of artificial filters and the cost of operation of sewage farms. I do not think, however, that Mr. Cameron, who installed the septic tank at Exeter and started us all on these tank investigations, has ever claimed that the tank would destroy sludge to such an extent as some of the latter advocates of the system claim. If you read his testimony before the Royal Commission on Sewage Disposal you will find him frankly acknowledging that the tank accumulates sludge. In fact, after 2 years' use, 40 per cent. of the tank's capacity was so filled. Mr. Cameron stated, however, that this was only about one-ninth as much as would have accumulated if the

sludge from chemically precipitating a like volume of sewage had been allowed to accumulate. This seems a pretty strong statement in regard to sludge destruction, but he modifies it, apparently unwittingly, by the further statement that much of the fine matter in suspension in the sewage passes away in the tank effluent. As a guess I should say that if the fine sediment had been measured it would account for a considerable portion of the non-accumulating sludge. It does not follow, however, that because the septic tank appeals to them, or is of value to them, that it would necessarily be of great value generally to us in New England even if as successful in destroying sludge as its most ardent advocates have claimed, although, of course, there are many sections of the country where it would be, the difference being the different conditions in regard to available sand areas, etc., prevailing here. It would certainly be of great advantage in some places, such as Worcester, for instance, if it could or would destroy such a large percentage of suspended organic matter as some experiments and installations upon a fairly large scale have seemed to show judging from the published results.

During the past 6 years we have operated, in pursuit of different investigations, 5 or 6 different septic tanks at the Lawrence Experiment Station. The oldest one, known as Septic Tank A, has received regular station sewage for something more than 6 years. This is a small wooden tank, with a capacity of only about 250 gallons. I do not think, however, that the value of the results obtained from it, or by its use, is any way affected by the fact that it is of small instead of great capacity. I see no reason why the relation of sludge destroyed to that entering should not be the same as with a larger tank if the sewage is of the same quality. Looking over the results obtained from the use of this tank during its period of operation, I find that the average sewage entering has 4.49 parts of free ammonia and 0.80 of a part of albuminoid ammonia. That is, it has been a sewage considerably stronger than the average sewage reaching filtration areas in Massachusetts. The effluent of the tank has had on an average of 4.45 parts free ammonia and 0.39 of a part of albuminoid ammonia; that is, during the 6 years of operation slightly more than 50 per cent. of the albuminoid ammonia of the sewage entering the tank has not appeared in its effluent. It is a fact, however, that the work of the tank has been deteriorating year by year during the past 5 years, although its second year of operation gave better results than the first year. In 1899, 62 per cent. of the albuminoid ammonia of the entering sewage did not appear in the effluent; in 1900, 60 per cent.; in 1901, 51 per cent.;

in 1902, 39 per cent., and in 1903, 35 per cent. One reason for this deterioration is undoubtedly due to the fact that the capacity of the tank has decreased owing to the increase of the sludge within it, and, therefore, the volume of sewage applied has passed through the tank in a shorter number of hours, daily giving less chance for sedimentation to occur. The percentage removal of nitrogenous organic matter in suspension in the sewage entering this tank, as shown by albuminoid determination, has decreased steadily from 85 per cent. to about 50 per cent. in the past 6 years. No sludge has ever been removed from the tank, and at the end of 1903 about 40 per cent. of its capacity is filled with it. The actual solid matter removed from the sewage by the tank, as shown by determination of the solids of the applied sewage and effluent, amounted to 22 per cent. in 1902, and 29 per cent. in 1903. The combustible organic matters removed in 1902 amounted to 35 per cent., and in 1903 to 45 per cent., and there were only about 7 parts of solids in suspension in the effluent of the tank in 1903 compared with over 20 parts in the sewage entering.

The Kjeldahl determinations made upon the sewage entering and in the effluent from Septic Tank A during the year 1903 show a removal of approximately 50 per cent. of organic matter against 34 per cent. as shown, as I have stated, by the albuminoid ammonia determinations.

A much larger tank was operated by the Board at Andover for a period of rather more than 4 years, this being a wooden tank, with a capacity of 9000 gallons, the sewage being approximately 15 to 18 hours in passing through this tank. The results in regard to the removal of organic matter for the entire period were about the same as with the smaller tank, namely, an average of about 47 per cent., as shown by the determinations of albuminoid ammonia, in the sewage entering and the effluent from the tank. This tank was operated without the removal of sludge, and at the end of the period of operation about 20 per cent. of the capacity of the tank was filled with the accumulated matters. The sewage entering this tank was very strong, averaging 7.5 parts free ammonia and 1.3 albuminoid ammonia, and the effluent from the tank averaged 7.1 parts free ammonia and 0.69 of a part albuminoid ammonia. The albuminoid ammonia in suspension of the sewage entering the tank averaged about 0.55 of a part, while that of the effluent was only 0.19 of a part, a removal of about 65 per cent. This tank was doing as good work at the end of its period of operation as at the beginning as far as removal of sludge was concerned.

During the past year a septic tank, known as Septic Tank E,

has been in operation at Lawrence, it seemed to us, owing to many published reports in regard to the large amount of organic matter removed by the operation of some septic tanks, that the character of the water supply in these different localities, or the ground water entering the sewers, might have some effect upon this removal. That is, it was thought that where a particularly hard water was in use, or hard water entered the sewers, a species of chemical precipitation might occur in the tank owing to the passing out of solution of some of the mineral salts, causing the hardness, while the sewage was undergoing tank action. Therefore, the sewage entering this septic tank was made very hard by the addition of such mineral salts as we find in hard waters—lime, magnesia, chlorides, etc. While some such action as we expected occurred, the principal result from this tank was to explain in a way the difference in the character or strength of the odor of septic tank effluents. For instance, the effluent from our Septic Tank A, at Lawrence, while always having a considerable odor, is not particularly offensive. The effluent of this tank, however, was exceedingly offensive, and was caused by the generation or liberation of sulphureted hydrogen from the sewage, this being due to the decomposition of the sulphates added to make the sewage hard. The gases set free from Septic Tank A upon analyses have never shown any sulphureted hydrogen, but there was a large amount in the effluent of this tank. You have all read, of course, of the disputes as to whether septic sewage is ill-smelling or not, and naturally, no doubt, it varies very much at different places, due to some such local reason as this experiment might indicate. Mr. Cameron, in the testimony already referred to, stated that in his opinion the difference was due to time of passage, but this cannot, I believe, account for all discrepancies on the odor discussion.

Another experiment was made upon the treatment of sludge liquor in a septic tank. It seemed probable, from long-continued observations and experiments, that while the passage of sewage through a septic tank may in some instances make the sewage more easily purified upon filters after tank action, still this is not a valuable function of the tank. It is really the destruction of the sludge. Therefore, this experiment, as I have stated, was made. An exceedingly strong sludge liquor from settling sewage was passed into this tank, the solid matters in the sewage, as it entered, having an average loss upon ignition of 261 parts, while the effluent had only 45 parts loss on ignition, that is, 78 per cent. less. This sewage entering had 4.5 parts free ammonia, while the effluent had 8.7 parts free ammonia. The albuminoid ammonia of this sewage was 3.38

parts and that of the effluent 0.85 of a part; that is to say, the free ammonia nearly doubled while the sewage was passing through the tank, and the effluent contained only 25 per cent. as much albuminoid ammonia as the entering sewage. At the end of 1 year of the operation of this tank the sludge within it amounted to 50 per cent. of its capacity, filled 1 compartment and practically prevented the operation of the tank. At this time the tank contained about 20 per cent. of the organic matter of the entering sewage, and this compared with the organic matter in the effluent showed that 58 per cent. of this matter had been liquefied, given off as gas or otherwise changed by tank action.

The effluent of this tank was very hard to purify upon either intermittent or contact filters without good preliminary aëration. This was due not only to the strength of the effluent, but also to the toxins in the sewage and to the quick exhaustion of oxygen within the filters; that is, an oxidation of organic matter occurred without the formation of nitrates. A septic tank operated during the past year, which is divided into 5 compartments and in which practically all the sludge is retained in the first 2, has not affected the sewage in this way—that is, it is easily purified; but when the sewage remained a number of days mixed with, or above, the putrefying sludge in Septic Tank B previously described, it became of such a quality that it could not be easily purified. The sewage used at Lawrence in these experiments is different from that reaching some areas in the State—although similar to that reaching others—and probably more easily acted upon by the bacteria. When one sees the nature of the sludge retained in some of the larger settling tanks, or upon the surface of some areas, it looks as if it would be a more difficult proposition for the bacteria to work upon than the Lawrence sludge.

BY PROF. LEONARD P. KINNICUTT, WORCESTER POLYTECHNIC INSTITUTE.

I thank you, Mr. Chairman, for calling attention to the work done by the Worcester Polytechnic Institute in attempting to solve some of the problems connected with the so-called septic tank treatment of sewage. This work, however, has been fully reported in print, and I think is known to most of the gentlemen present, and I will only say that the results of the experiments, which were carried on for over 2 years by Mr. Eddy, Superintendent of the Worcester Sewer Department, and myself, with Worcester sewage, and in a closed septic tank holding 1500 gallons, showed that, with an acid iron sewage containing about 74 parts of total solids, of which

15 parts were ferrous sulphate—an amount of organic matter represented by about 0.6 parts albuminoid ammonia, and an acidity equal to 10 parts of sulphuric acid in 100,000 parts—about $\frac{1}{4}$ of the total solids, 26 per cent. of the organic matter as shown by the albuminoid ammonia, were removed from the sewage, and that the amount of sludge, changed into soluble or gaseous substances, in other words liquefied, was about 25 per cent. of the total solid matter taken from the sewage by the action of the tank.

As to the action of the septic tank on sewage it is what is chemically known as hydrolysis, *i. e.*, the breaking down of complex organic compounds by the absorption or addition of water, which, in the case of the septic tank, is brought about by the action of bacteria or their products the enzymes. The organic substances contained in domestic sewage can roughly be divided into 3 classes—the albuminoids, the fats and the carbohydrates. The albuminoids are organic nitrogen compounds containing a small amount of sulphur, of very complex composition, which can possibly be expressed by the chemical formula $C_{72}H_{112}S.N_{18}O_{22}$. These compounds by hydrolysis are resolved first into peptones, which are soluble in water, and then further broken down, giving organic acids containing nitrogen and organic compounds free from nitrogen. In this process of breaking down of the albuminoids, gaseous products, carbon dioxide, marsh gas, hydrogen, ammonia, nitrogen and probably more or less sulphide of hydrogen are evolved. The fats by the same process of hydrolysis are resolved into organic acids and glycerine, while the carbohydrates yield fermentable sugar, which breaks up into alcohol and carbon dioxide. By this process of hydrolysis, then, the complex organic compounds are broken down into simpler compounds, with the results that a certain amount of the insoluble organic matter in the sewage is rendered soluble, a certain amount of organic matter is removed from the sewage, and the organic matter which remains is more easily acted upon by what are called the nitrifying bacteria. This process of hydrolysis is, as we all believe, brought about by a certain class of bacteria, and the primary object of the septic tank is to cultivate the bacteria capable of producing hydrolysis of these organic substances.

Bacteria, which are believed to be essential for this decomposition of organic matter, or at least are capable of doing this work, are intestinal bacteria. Trade waste does not contain these organisms, indeed it very often contains elements that militate against the life of all bacteria; thus Professor Houston estimates that the sewage of London contains 6,000,000 bacteria to the cubic centimeter, while, according to Dr. Leith, the sewage of the large manufacturing city

of Birmingham contains only 400,000 to the cubic centimeter. Is it not very possible that the reported failure of the septic tank process in certain cases may be due to deficiency in bacterial life, and especially to the class of bacteria especially essential to bring about these first putrefactive changes? It seems to me greater attention should be paid, than is often the case, to the bacterial content of the sewage that enters the septic tank, and further study should be made as to the best method of inoculating a sewage and of cultivating the growth of special forms of bacteria.

I do not for a moment wish it to be thought that the reactions I have outlined give, by any means, a complete explanation of what takes place in a septic tank. Our knowledge is far too limited at the present time to give a complete or even clear explanation of what goes on in the septic tank. It is merely an outline from a chemical point of view how a mixture of complex compounds are transformed into a mixture of much simpler substances. In the process of transformation that takes place in the tank, two things are especially noticeable to the eye—the evolution of gas and the formation of scum over the surface of the liquid. The gas is chiefly a mixture of carbon dioxide and marsh gas, containing at times more or less hydrogen, and the amount, when a tank is in best working condition, will average about 1 cubic foot per 100 gallons of sewage. I also believe, though I am not at the present moment willing to state it as a fact, that much can be told as to whether or not the best results are being obtained in the septic tank process by determining the amount of marsh gas contained in the mixture of gases evolved from the tank, and that failure to obtain about 1 cubic foot of gas for every 100 gallons of sewage, or of a gas containing less than 70 per cent. of marsh gas, is a sign that the best results are not being obtained.

The formation of scum has caused possibly as much discussion as any other factor in connection with the septic tank. As the gases rise to the surface of the liquid they bring with them matters in suspension which tend to form a tough gelatinous scum over the surface of the tank. The scum seems to be more readily formed in a covered tank, where the temperature is more equal and invariably higher than in an open tank. In a tank where sedimentation is fairly complete the scum is often very thin. If a sewage contains very little heavy material and a large amount of light material, especially paper, fibrous and woolly matter, the scum may become so thick that it is very difficult to remove. The formation of the scum depends a great deal on the character of the sewage. There will, as a rule, be less formed with a sewage containing street wash-

ings than in the sewage from the separate system; less from a sewage containing mineral organic waste, as iron salts, cement trade waste, etc., than from one containing the refuse from cotton and woolen mills. This question of the formation of scum has not been as carefully studied as it deserves, though even at the present time we can, knowing the character of the sewage, predict to a certain extent the character of the scum that will be formed, and prevent by a suitable subdivision of the tank the formation of a too troublesome sludge over at least a portion of the tank.

That the septic tank or, as I prefer to call it, the hydrolytic tank has its place in the treatment of sewage, I think few outside of Massachusetts will question. I believe it is not only an essential feature in contact bed and percolating filter systems, but also has its place where irrigation and intermittent sand filtration methods are employed. In this connection I should like to refer to some statements made by Dr. John Duncan Watson, engineer in charge of the Birmingham Sewage Disposal Works, in a recent lecture on "Purification of Sewage, with Special Refeience to Sewage Disposal at Birmingham," which lecture, I would say in passing, is one of the best expositions on the subject I have ever read. At Birmingham, as you all know, the method of final purification is irrigation. Formerly the suspended matter was removed by the addition of lime, the sewage containing a large amount of iron salts. Now the suspended matter is removed by sedimentation and septic tanks.

As regards septic tanks, Dr. Watson says: "Difference of opinion has arisen as to the relative merits of anaërobic and aërobic organisms in promoting liquefaction, but it is now almost universally admitted that the cultivation of the anaërobe is an object of the first importance in the first stage of sewage purification. It stands to reason that to attempt to work organisms so evidently dissimilar simultaneously in the same tank will lead to unsatisfactory results. An additional reason for the cultivation of the anaërobe at this stage of the purification process is that the breaking down of fatty matter and cellulose, which embraces substances like paper, straw, fiber, etc., is entirely due to the action of the liquefying anaërobes.

"The Manchester experiments demonstrated that an open tank was quite as efficient in obtaining liquefaction as a closed one; and as the cost of the latter is so much greater, it is not likely to become popular, and probably will not be adopted in future unless for special local reasons. The results which were obtained at Manchester are in accord with the experience which we have had at Saltley; and I am glad to say that notwithstanding the fact that our septic tanks

there, forming, perhaps, the largest collection of such tanks in the world, have, during the past two and one-half years, been entirely free from nuisance.

"It is impossible to give an accurate figure which would represent the amount of sludge the septic tank is capable of liquefying, so much depends on the nature of sewage treated, the length of time it is confined in the septic tank and the amount of suspended matter removed by screening and straining before it reaches the septic tank. The following statement of the result obtained at Saltley, where 20 large tanks, subject to fluctuations, are in daily use, will afford some evidence of the liquefaction obtained under adverse conditions. Crude sewage, as it enters the sedimentation tanks, contains 39.45 grains per U. S. gallon of suspended matter. This is disposed of as follows: 20 grains per gallon, or about one-half of the whole, is ejected down the sludge main and disposed of on land; 14.26 leaves the septic tanks in the form of humus; 5.17 is liquefied and given off in gas."

As showing the amount of purification that takes place in the sedimentation and septic tanks at Birmingham, the following data, taken from a table given by Dr. Watson, are interesting and valuable:

PARTS PER 1,000,000.

Nature of Sample.	Nitrates, etc., as Nitrogen.	Dissolved Solids.	Suspended Solids.	Free Ammonia.	Albuminoid Ammonia.
Computed Average Sewage	0.70	127.6	68.6	4.77	1.73
Sedimentation Tank . . .	0.73	131.8	34.6	4.58	1.32
Septic Tank	0.31	117.9	27.4	5.84	1.01

Nature of Sample.	Chlorine.	Oxygen absorbed in 4 hours.		Alkalinity.	Percentage of Purification.	
		Filtered.	Unfiltered.		Albuminoid Ammonia.	Oxygen Absorption.
Computed Average Sewage	21.8	18.22	9.63	22.2		
Sedimentation Tank . . .	20.6	14.93	9.25	18.2	23.7	18.1
Septic Tank	21.3	12.09	7.18	26.9	41.6	33.6

And in closing, I should like to quote from a personal letter received from Dr. Watson last month, in which he says: "It may interest you to know that we have just cleaned out a septic tank

which has been in use continuously for four years and two months. The amount of irreducible residue occupying the bottom of the tank was equal to nearly one-third of the tank capacity, and I send herewith a copy of the analyses which our chemist has made of that residuum:

ANALYSES.

Total organic matter in dry sludge	44.67	per cent.
" nitrogen in dry sludge	2.47	"
" inorganic matter in dry sludge	55.33	"

The inorganic matter contains:

Siliceous matter (sand, etc.)	20.00	per cent.
Oxide of copper	1.71	"
Oxides of iron and aluminum	20.00	"
" " Zinc, Manganese and Nickel, about	5.00	"
Lime and Magnesia, about	7.00	"
Oxides of Phosphorus and Alkalies, about	2.00	"

BY MR. C.-E. A. WINSLOW, BIOLOGIST, IN CHARGE OF THE SEWAGE EXPERIMENT STATION OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

It is said that young men talk about what they are doing, old men about what they have done and fools about what they are going to do. I am afraid that by calling upon me to-night you force me to place myself in the latter class.

The newest of our septic tanks has been in operation about 2 days, and the oldest of them only 6 months, so that we feel we are just beginning to get a glimmering of light as to the nature of the problem before us. As Mr. Barbour has said, the septic tank is a "live issue," a sort of balanced aquarium, in which certain organisms are carrying out the processes of fermentation; and these bacteria are susceptible to the slightest changes in their environment,—the chemical composition of the sewage, the temperature, and particularly the time during which the process is prolonged, being the main variable factors. Of these, the time element is perhaps the most easily controlled, and we have begun our investigations with this, studying at first very long periods, longer than would be used in practice, since such extreme cases give the best clues to the theoretical principles involved.

The action of the septic tank is apparently two-fold. In the first place we desire to get the solid matter liquefied. In the second place we desire to get the organic matter, in solution, into such a condition that it will be readily acted upon in the subsequent processes. We have found in the former respect that a too prolonged period of

action has an unfavorable effect on the liquefying action, 2 septic tanks run at such a rate that their contents were changed once in 48 hours showing on the average more suspended matter in the effluent than did 2 tanks run at twice this rate.

Furthermore, we have already a little evidence as to the injurious effects of excessive septic action upon subsequent processes of purification. We have 2 systems of double contact beds, 1 pair taking raw sewage and the other sewage septicized for 30 hours. Now, while the septic sewage is more readily acted upon in its passage through the first contact bed, showing a removal of 52 per cent. total and 75 per cent. suspended albuminoid ammonia against 27 per cent. and 62 per cent. for the raw sewage, the effluent appears to be of such a nature that the process in the second contact bed is seriously hampered. The final effluent from the system taking septic sewage shows 60 per cent. removal of total albuminoid ammonia and 79 per cent. removal of suspended albuminoid ammonia against 69 per cent. and 90 per cent. in the case of the raw sewage.

We are planning at present to extend this study by comparing the results of shorter periods of septic action, but evidently it is easily possible to carry the septic process too far.

I am glad of this opportunity to say a word about our station and its purpose. Some of you may know that the Sewage Experiment Station of the Massachusetts Institute of Technology was established last June as the result of a gift by a private individual, whose name is not made public. We have now installed 4 intermittent filters, 6 septic tanks, 9 contact filters and 3 continuous or trickling filters, the capacity of the tanks varying from 64 to 96 cubic feet. Our aims are first educational, since the station affords an unrivaled opportunity for the students at the Institute to study sewage purification; but we also hope that we may in some small way be able to supplement with original investigations the splendid work that is being carried on by the State Board of Health. There is still much to be done on this problem, as you will realize when you consider that we know practically nothing about the nature of the specific organisms which are the active agents involved.

In our work we are very anxious to get the assistance of all those who are interested in the sewage problem. We should like to have all the members of this Section visit our plant, located at 786 Albany Street, at the corner of Massachusetts Avenue, on the line of the largest Boston sewer. We should like to have your advice as to the work we are now carrying on and your suggestions as to researches in the future.

I suppose that one of the aims of this Sanitary Section is to

bring together those occupied with theoretical experimentation and those engaged in the operation of plants on a large scale. I do not know how much in the future the theoretical man may contribute to the practical man, but I know from the theoretical standpoint that only so far as we keep in touch with the actual problems of the day do we feel that we are performing our function to the Institute. I therefore want to express my thanks to the members of the Society who have organized this Section for permitting those of us who are not members of the Boston Society of Civil Engineers to come here and to listen to the interesting papers which have been read to-night, and for the promise of many more such stimulating meetings in the future.

BY MR. F. HERBERT SNOW, CIVIL ENGINEER, BOSTON.

The speaker came here to-night with the avowed purpose of remaining silent, for the reason that he is actively engaged in defending several of the suits in litigation, to which reference has been made; but as this seems to be a kind of experience meeting, the "power" has been coming on as the moments went by and other speakers have left untouched one important phase of the subject, so that now, at the close of the evening, he is really glad and anxious to offer a few remarks, and should anything he may say prove of advantage to the attorneys for the claimants in the said cases, they are welcome to it.

In passing, as one of the members of the Boston Society of Civil Engineers, interested in the formation and success of this Sanitary Section, the speaker wishes to say, that the members of the Sanitary Section have occasion to congratulate themselves on this auspicious beginning of its career: First, because of the gathering of so distinguished a body of original investigators of the septic treatment of sewage as we see about this board; and, second, because at the outset the discussion has taken the form of such broad and free expression of opinion as to demonstrate the fact that the Association is to be more than an "Amen" corner of the Boston Society of Civil Engineers.

While much is known about the putrefying process of sewage disposal, as appears from this evening's consideration of the subject, the speaker has been notably impressed by the knowledge which is lacking, or, in other words, by his desire for certain information, which information, he infers, no one is able to supply, and the natural conclusion, to which it would seem all present must hold, is that the art is very much in its infancy.

The discussion, simmered down, results in this—if the speaker

may be pardoned the conceit—that opinions, rather than practically demonstrated conclusions, must obtain at this stage of the development; but it is only fair to add that those expressed here to-night, while at wide variance in some respects of importance, are based upon personal researches, experiment and experience, and therefore must carry with them great weight.

The investigator who claims not to be an advocate deceives himself. He is such to the extent his mind is enlightened upon the particular subject he is following, and he may be so engrossed in this one line of thought and its collateral work as to lose sight of the real significance of other observed facts. Such has been the case with respect to the attitude of investigators and engineers during the greater part of the last 20 years toward the putrefying process in sewage disposal as disinct from the oxidizing process.

From the earliest times putrefaction has caused trouble and incidentally death, and efforts have been continually made to prevent it. Fifty years ago neighborhood sewage settling tanks were somewhat generally abandoned in England on account of the inevitable nuisance they created, and facilities for handling and treating sewage in as fresh a state as possible were promoted and continued all along the years. About 1878 an innovation was established by one Dr. Mueller, of Berlin, who, in describing his invention, said, as nearly as can be recalled at this moment, that while on one hand the adoption of flush sewers was becoming quite general, so was also, on the other hand, the demand for the use of the water necessarily wasted in operating the sewers, and that this reuse of the water required that it be purified, but that the difficulty in accomplishing this lay in the contained organic matter and the putrefaction it involved; and, further, that while the attempt to remove this nuisance or putrefaction by dilution on a large scale, or by antiseptics or chemicals, or by oxidation in filters or irrigation on land had all proved futile, and investigators had concluded that on purely chemical or mechanical lines the object aimed at, that is, the purification of the organic matter by methods which obviate as far as practicable any putrefaction, was not attainable, his process aimed at purification by promoting the agencies of putrefaction by the methodical cultivation of those small "leaven-like" organisms, to which science was then ascribing the phenomena of fermentation, acidification and putrefaction.

In his tank or apparatus he brought into requisition these organisms, and effected thereby the complete mineralization or "reduction to simple inorganic compounds of the organic matters in the liquid."

So here we see was a recognition of the so-called modern septic process. Four years later, in 1882, one Louis Mouras, of France, patented a sewage-liquefying apparatus, which had for its object the retention and destruction of the solids in sewage in the tank, and the discharge therefrom of liquid only, the intention being to obviate deposits in sewers and thereby reduce the flow in the sewers required for scouring them and carrying away the heavier matters.

This invention was very extensively utilized in Paris and is still in use in some parts of France.

The American right to this apparatus was granted in 1882, and was very fully described with cuts in the *Engineering News* of that year. This article gave an account of the experiment conducted with the apparatus, and showed how solid matters were effectually liquefied in the tank.

Anyone conversant with the art of sewage disposal at that time and with American literature on the subject must have known about this article and the intentional use of the putrefaction process in sewage disposal.

In proof of this we find that Mr. Edward S. Philbrick, whom some of you may have known, and who was a recognized authority on sanitary matters, in a series of articles published the very next year, 1883, described an apparatus of his own, perfected after several years' experiment, which provided for the use of the putrefactive action, and which as perfected he gave to the public for what it was worth, with the comment that the method had been so long in use that claims to proprietorship were not considered valid in his estimation.

His apparatus comprised, among other features, a compartment in which solids were to be separated from the liquid sewage, and retained and become macerated and finely divided by fermentation. So here was an acknowledged American authority, in 1883, recognizing and intentionally using the putrefaction process as described by Mouras and Mueller. But he cautioned its use, and recommended strict attention to proper ventilation of the odors accompanying putrefaction.

And we find no less an apostle of oxidation than the late Geo. E. Waring, stating in his last book published in 1895, in referring to his system of disposal of wastes of isolated houses, as near as can be recalled at this moment,—that in the first of the 2 tanks all of the characteristics of the old-time cesspool may be found, where the sediment and the scum are in a seething mass of putrefaction, emitting foul odors which are objectionable, but he adds, "No way

has yet been discovered in which the foul deposit chamber can be dispensed with."

So we see that the question of a nuisance was a drawback to the putrefaction process, and it was this bugaboo of a nuisance which has agitated the minds of the citizens of every municipality in Massachusetts when a sewage disposal plant has been constructed. It was notably so at Medfield, in 1886, when Elliot Clarke recommended intermittent filtration, and notably so at all the earlier places of installation in the State.

It appears, and is the fact, that while the liquefying putrefying process was known, the sanitary aspect of the disposal problem was considered paramount, and therefore the whole trend of thought and practical endeavor was, during all these years, toward the oxidizing non-offensive process and away from the putrefactive offensive one.

This accounts for the fact that up to 1897 investigators lost sight of the possible advantages which lay in promoting putrefaction to a stage beyond which it had been previously used. But when Cameron, in 1897, exploited his septic tank, an impetus was at once given to research along similar lines.

But even now, after several years of special study, the knowledge of how best to promote liquefaction to a desirable degree, and what constitutes this desirable degree, is a minus quantity, and the observed facts are most contradictory.

Even on the question of practicability and utility of this process we have at loggerheads, here to-night, the leading exponents of the art in America.

The speaker wishes to record his testimony at this time as against the policy of the general adoption of the modern septic tank. The tank of the day is more than likely to cause a serious nuisance in the neighborhood of the installation, unless extreme precautions are adopted. The disposal of the insoluble mineral sludge, together with more or less organic matter, is a most difficult problem, and in every case the speaker knows about is accompanied by offensive odors.

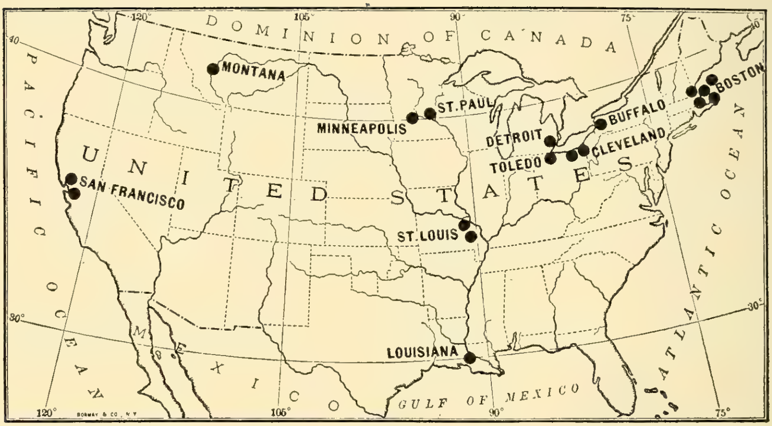
Whether these difficulties are inherent in the process, or may be eliminated by attention to details of design and operation, remains yet to be demonstrated.

The expense of doing this, if it can be done, is a factor for consideration, and also the important fact that the process is on the wrong side of the sanitary fence anyway.

Still further, if the chemical changes in the liquid of any par-

ticular case is likely to render the sewage more difficult to purify, there is an added doubt as to the advisability of the adoption of the process.

So far as the speaker is able to judge at the present time, from his lifetime experience and observation, the staling of sewage in settling tank, disposal of solids while in a comparatively fresh state, and in small quantities, and the oxidation of the supernatant liquid by one of several approved methods, is the safest and very best system for general adoption.



MAP

Showing the locations of the Societies forming

THE ASSOCIATION OF ENGINEERING SOCIETIES.

(Each dot represents a membership of one hundred, or fraction thereof over fifty.)

ERRATA.

Paper on Steel-Concrete Work of the Harvard Stadium. By Lewis J. Johnson.

Plates II, III, IV, Scale, 1 inch = 6 feet.

Editors reprinting articles from this journal are requested to credit not only the JOURNAL, but also the Society before which such articles were read.

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THE DESIGN OF THE STEEL-CONCRETE WORK OF THE HARVARD STADIUM.

BY LEWIS J. JOHNSON, MEMBER OF THE BOSTON SOCIETY OF CIVIL ENGINEERS.

[Read before the Society, December 8, 1903.*]

ALTHOUGH the Harvard Stadium is well known in its general character to many members of this Society, it may be well at the outset to recall briefly some of its main features.

The Stadium is a steel-concrete and steel grand-stand, U-shaped in plan, to accommodate some 23,000 spectators at football and other games on Soldier's Field, in the Brighton District of Boston. It is intended to furnish a permanent, fireproof and architecturally pleasing structure in place of the short-lived and unsightly wooden grand-stands hitherto in use. Figs. 1 and 2 show the general appearance of the structure when work was discontinued for the winter. The object in the foreground of Fig. 2 is an aisle slab (described below) in an inverted position.

The structure consists essentially of five parallel rows of steel-concrete girders, columns and piers, extending around the U from tip to tip, and supporting a system of steel beams and trusses crossing them transversely (Fig. 3 and Pl. I). This transverse steel work in turn supports lines of steel-concrete slabs running around the U and forming the seating surface. The rows of steel-concrete work are designated by the letters A, B, C, D and E, counting from the interior outward. Fig. 4 shows the four inside rows on the curve, rows A and D not yet stripped. Row A, besides supporting ends of steel beams, includes the front parapet, a wall about nine feet

* Manuscript received January 11, 1904.—Secretary, Ass'n of Eng. Socs.

in height and continuous around the U. Rows B and C support only steel work; row D supports the outer ends of the steel work and shares with row E the support of two steel-concrete promenades or galleries about twenty feet in width at levels of about 25 and 50 feet above the ground and running from tip to tip of the Stadium. Row E is a line of hollow piers separated by two stories of arched openings, and ultimately to carry a wall at the third story which, with the aid of a colonnade surmounting row D, will support the roof of the upper promenade. The openings of the lower of the two arcades of row E afford access to the stairways to the seating surface, and the openings of the upper afford outlooks from the promenade behind them.

The steel-concrete work includes, besides all the columns, piers, main girders, floors and the seating surface above mentioned, the outside and end walls, the staircases and all parapets and railings. The foundations are all of concrete, some reinforced, some plain. All parts exposed directly to the weather are of steel-concrete.

The developed length of the U at the outside row is 1390 feet, and the uniform width across from front to back of the wings of the U is 98 feet. The area actually under cover is some 120,000 square feet, about 40 per cent. of which is devoted to the semicircular end, and the rest to the two straight wings. The lowest seat is about 8 feet and the highest about 48 feet above finished grade. The number of rows of seats is 31.

The over-all length of the Stadium is 575 feet, and the width is 420 feet, both exclusive of some small towers to occur at each tip of the U and a flight of two or three steps to extend the whole length of the outside. The highest part of the structure now finished is about 53 feet above the ground, but the addition of the covering for the upper promenade will make the final height 71 feet.

Durability, adaptability to rapid construction, coupled with its æsthetic possibilities and moderate cost, are the qualities which led to the use of steel-concrete to the extent above described. The steel work used to supplement it is under cover, accessible for painting, and will be kept isolated from combustibles, and is hence deemed acceptable from the point of view of permanence. It was fabricated while the concrete to support it was being placed, and much time was thus saved, and, under the circumstances, probably some money.

Most of the concrete work was cast in place in wooden forms in the ordinary way, but the slabs of which the seating surface is composed were of a special mixture and were cast in sand molds

FIG. 1. THE HARVARD STADIUM IN APRIL, 1904, WITH SOME OF THE TEMPORARY WOODEN SEATS IN THE REAR REMOVED TO MAKE WAY FOR THE PERMANENT CONCRETE SEATS.

Fig. 2. Western Façade of the Stadium in April, 1904.

upon the ground in units weighing about 1200 pounds each, and after hardening were hoisted into place and set upon the supports which were meanwhile being prepared for them. The concrete cast in the wooden forms is to be picked so as to remove the board marks, while the seat slabs have a satisfactory surface given by the sand mold. The steel reinforcement in all the concrete consisted of Ransome cold-twisted square steel bars (ranging in size from quarter-inch to inch), supplemented in the seat slabs with a special wire netting with rectangular meshes, electrically welded at the joints.

The concrete was mixed by machinery, two Smith mixers operated by gasoline engines constituting the plant for the purpose.

Constants for use in the concrete design were taken at figures to be regarded as suitable for ordinary Portland cement concrete of 1 : 3 : 6 mixture, though the concrete used was of varying mixtures, always considerably richer than 1 : 3 : 6. An attempt was made to use concrete of special mixtures for special places in the work, but this was found to be impracticable under the conditions—except, as above stated, in the case of the seat slabs.

Three grand divisions of the work went on simultaneously—the casting of the standing concrete (work going on on both wings at once), the manufacture of the structural steel work and of the concrete slabs. The results of these three operations were assembled by the setting of the steel work and the slabs.

The Boston Bridge Works had the contract for the manufacture and erection of the structural steel, but the steel-concrete work was done by day labor, the Aberthaw Construction Company being employed as purchasing agents and as field executives to devise, install and operate the steel-concrete construction plant.

The Harvard Athletic Association furnished the general and detailed designs for the entire structure, the architecture being in the hands of Messrs. C. F. McKim and G. B. de Gersdorff, of New York; the engineering design was the work of Mr. J. R. Worcester and the writer, and the whole was under the direction of Professor I. N. Hollis.

The foundations are of the simplest character, as borings showed only hard gravel and clay to a depth of at least 40 feet. They are mere concrete or steel-concrete blocks laid on the natural ground just below frost, so proportioned as to keep the maximum pressure on the ground from exceeding 7000 pounds per square foot.

The methods and principles followed in the design of the re-

mainder of the concrete work may conveniently be taken up under three general heads, viz:

(1) Columns.
(2) Girders (simple and cantilever).
(3) Walls and parapets.

COLUMNS.

All the columns contain twisted rods in the form of verticals at the corners, with or without horizontal hoops at close intervals (Pl. II). This steel was not, however, counted on as furnishing compressive resistance. Its utility was conceived to lie in withstanding any slight flexure that might come upon the columns from lateral forces due to temperature changes or other causes. This reinforcement consisted of three-eighths and half-inch rods, depending on the size of the column, one such rod being placed near each corner of the column. In order to guard against the risk of such slender rods buckling when too near the surface, square hoops of quarter-inch rods encompass them in horizontal planes at intervals, keeping their free or unsupported lengths within reasonable limits.

Besides adding flexural strength, as just described, this steel furnishes some protection against the failure by shearing on planes inclined about 55 degrees to the horizon characteristic of prisms of materials like plain concrete. It was not overlooked that Professor Hatt found* reinforced concrete prisms to stand compression rather less well than plain ones, but it was by no means clear that his conditions were repeated in the Stadium, and the desirability of a slight amount of flexural strength already mentioned, and of the increased protection furnished by the steel against shrinkage or other cracks, made it seem on the whole preferable to use it. The columns proper range in size from 14 x 14 inches to 24 x 33 inches. Besides these, and designed in the same general way, with corner vertical rods and horizontal hoops, except that they are hollow, are the piers showing in the outside wall and already mentioned, which are externally 66 x 36 inches (Pl. Vb), the walls along the 66-inch side being 4 inches thick and the other two 6 to 8 inches thick, the 8 and 6-inch ends being counted on as furnishing the whole compressive strength.

The cross-sections of the columns were determined by applying an allowable compressive stress of 350 to 400 pounds per square inch to the maximum combined live and dead load, increasing the results thus obtained whenever necessary to keep the ratio of the

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* *Engineering News*, July 17, 1902, p. 54.

length to least side of column down to about twelve, or to give round numbers for dimensions of the section. The structural steel work and concrete girders and struts were arranged to aid in keeping down the ratio of length to least side.

GIRDERS.

Out of the multitude of methods advanced for the design of steel-concrete girders, one based upon the observations of Prof. W. K. Hatt* was adopted throughout the work. This method seemed at least as rational as any; it gave conservative results, and (thanks to suggestions drawn from Mr. J. W. Schaub's letter in the *Engineering News* of April 30, 1903, p. 392) was very easy to use. This method ignores the tensile strength of the concrete, assumes a parabolic distribution of compressive stress and assigns a position to the neutral axis dependent upon the percentage which the cross-section of the steel tension flange bears to the whole cross-section of the girder. The proper and economical percentage of steel being dependent upon the relative cost of concrete and steel, about seven-tenths of one per cent. was a value commonly used in the Stadium, though it is a question whether a higher one might not have been generally more economical. With the assumed steel percentage, the maximum unit compressive stress in the concrete was determined for the load which would be supported at the appearance of the first crack on the tension side, and a fraction of this load was taken as the allowable load, this fraction being the ratio of the assumed allowable 500 pounds per square inch to that figured out by the parabolic principle as the maximum at the time of the first crack. Thus the maximum working compressive stress on the concrete is believed to be kept from exceeding 500 pounds to the square inch.

The appearance of the first crack was assumed to be accompanied by a tensile unit stress of 36,000 pounds per square inch in the steel. This is considerably below the elastic limit of the steel used, but it implies an elongation of about one-eighth of 1 per cent., which was taken to be as much as even armored concrete should be trusted to stretch without a crack.

To illustrate the meaning of the preceding, let us suppose the load upon a beam of given dimensions with a given percentage of steel located in a given position to be 75,000 pounds when the stress in the steel is at 36,000 pounds per square inch (assumed to accompany first crack), and that at the same time the maximum

* *Engineering News*, February 27, 1902, p. 170, and July 17, 1902, p. 53.

compressive stress on the concrete figures out by the parabolic principle to be 2000 pounds per square inch. The allowable value of the last quantity being assumed to be 500 pounds per square inch, the safe load on the girder would be $\frac{500}{2000}$ of 75,000 or 18,750, thus implying a working unit stress in the steel of only $\frac{500}{2000} \times 36{,}000$ pounds, or 9000 pounds, without counting on any assistance from the tensile strength of the concrete.

If, as would be the case with lower percentages of steel, the compression on the concrete should fall below 1125 at the appearance of the first crack, the steel would be the guiding factor instead of the concrete, and a fraction of the figured load would be chosen so as to keep the stress in the steel down to 16,000, even if the stress in the concrete should then run considerably below the allowable 500. The writer is inclined to avoid such low percentage of steel as generally lacking in economy, but circumstances may arise where thickness of slabs and depths of girders are determined by considerations of rigidity or of provision against abrasion. Here there can be no objection to a low steel percentage if the unit stress in the steel is kept within safe limits. It should be remembered that failure of a girder due to the fracture of the steel would be a sudden failure, far more dangerous to life than failure by cracking or crushing the concrete. Total failure would come about in the latter case gradually if at all, giving warning to the occupants of the structure. The abuse which a concrete girder with a fair proportion of steel will stand, and the warning which it will give before utter collapse and dropping its load, is one of the properties of steel-concrete not always appreciated.

The method above outlined may seem complicated and difficult to use, but with some predetermined constants on file for reference it is, on the contrary, very easy to use in practice, as will be shown later. It is admitted that from the point of view of rationality it has its weak points, as have other methods of steel-concrete computation. It leads to larger sections than some other methods professing to keep the unit-compressive stress in the concrete down to 500 pounds—producing an additional margin of safety not unwelcome in a structure like the Stadium.

The constants mentioned in the preceding paragraph may be worked out as values of K* such that the moment of resistance of a

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*Since this paper was put in type the writer has observed that Professor Hatt has suggested the use of K's of a similar character and has given numerical values for several of them. They will be found at the close of his paper, "Tests of Reinforced Concrete Beams," Proc. Am. Soc. Testing Materials, Vol. II, 1902.

concrete beam with breadth b and depth h may be expressed simply as $M = Kbh^2$, where K is a numerical coefficient depending, for a given u and $\frac{F_s}{E_c}$, simply on the steel percentage and can be taken from a table. A brief table of this sort is given herewith (Table I).

TABLE I.

VALUES OF K FOR VARIOUS PERCENTAGES, p, OF STEEL.

$u = 0.97$; $\frac{E_s}{E_c} = 7.5$; $f_s = 16{,}000$; $f_c = 500$.

p	K	p	K	p	K	p	K
.001	15	.006	66	.012	86	.030	116
.002	29	.007	70	.014	91	.040	125
.003	43	.008	74	.016	95	.050	133
.004	56	.009	77	.018	98		
.005	61	.010	80	.020	102		

It was compiled from Professor Hatt's* formulas for the resistance of beams at the first crack, following Mr. J. W. Schaub in using 7.5 for the ratio of E for steel in tension to that of concrete in compression, and modified for the lowest values of p as above explained to prevent the compressive stress in the concrete and the tensile strength of the steel from exceeding 500 and 16,000 pounds per square inch, respectively. The center of gravity of the steel in the section is supposed to be 97 per cent. of the depth of the beam from the top, this percentage being called u. As u frequently differs from 0.97, it should be noted that the h which should be used for determination of strength and steel percentage may be taken, within ordinary limits at least, at a value 97 per cent. of which will be the actual distance from the top of the girder to the center of gravity of the steel.

For example, suppose the maximum flexure in a given beam, including an allowance for its own weight to be 2,000,000 inch pounds and the proportion of steel to be assumed at 0.007, required the size of the beam. Taking 70 from the table as the proper value of K, $bh^2 = \frac{M}{K} = \frac{2{,}000{,}000}{70} = 28{,}570$ in.[3] The b and h can then be selected, b frequently being determined by a column width, or other such consideration. If b be 16 inches, h follows at $\sqrt{\frac{28{,}570}{16}} = 42.3$.

* *Engineering News*, July 17, 1902, p. 56.

If the center of gravity of the steel must be 2 inches above the lower face, making $u = \frac{42.3-2.0}{42.3} = 0.951$, *i. e.* less than 0.097, the actual gross depth of the beam to be used would be $2 + 0.97 \times 42.3 = 2 + 41.2 = 43.2$, or, for round numbers, say 44.

The weight of the beam being thus determined, the allowance for flexure due to this weight can be checked and the beam re-dimensioned if necessary. The dead weight of such beams being relatively a large item, this point needs attention accordingly. The b and h once selected $0.007 \times 16 \times 42.3$ will determine the total section of steel in the girder which can be made up of rods in various ways to suit conditions. The number of rods may be so large as to require their being put in several rows, and the u, and hence the effective depth of the girder, may thus be reduced so that b and h may have to be determined anew.

An alternative method of computing beam sections is that in which u is taken as unity, and the resulting h is the distance from the top of the beam to the center of gravity of the steel. The actual depth of the beam will be found by adding a suitable thickness of concrete below the steel to embed and protect it properly. Table II gives values of K to be used in this way, figured for the value of 7.5 for $\frac{E_s}{E_c}$ as before, and also for the values 6 and 10 for that ratio. The value 6 seems likely to be the one valid after the concrete is several months old and in actual normal service. It is interesting to see how comparatively slightly K is changed by these variations in $\frac{E_s}{E_c}$. The values of K in Table II, as well as in Table I, are for 500 pounds as the maximum compressive stress on the concrete, and 16,000 as the maximum tension in the steel. For values of p at 0.003 or less (for $\frac{E_s}{E_c} = 10$ this limit is 0.005) the concrete is at less than 500 pounds compression when the steel is at 16,000 pounds tension. Above these limits of p the steel is not worked up to 16,000 when the concrete is at 500 by a margin which increases with p.

The amount of concrete added below the steel should in all cases be kept at a moderate percentage of the depth, for though the concrete is not relied upon in tension, it will, of course, take some tension, and if it should reach much below the steel it would be likely to show a crack prematurely and expose the steel to corrosion. On the other hand this thickness must be sufficient to afford adequate fireproofing for the steel as well as protection against corrosion.

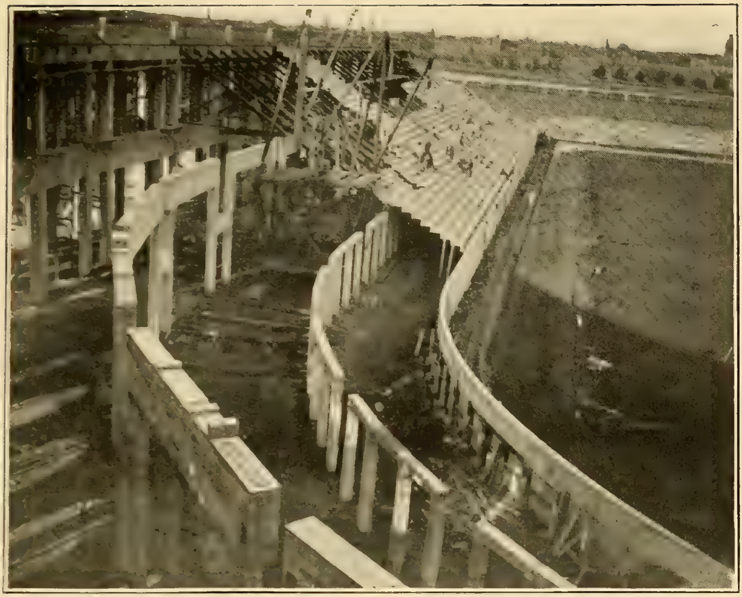

FIG. 3. PART OF CURVE AND WEST WING UNDER CONSTRUCTION.

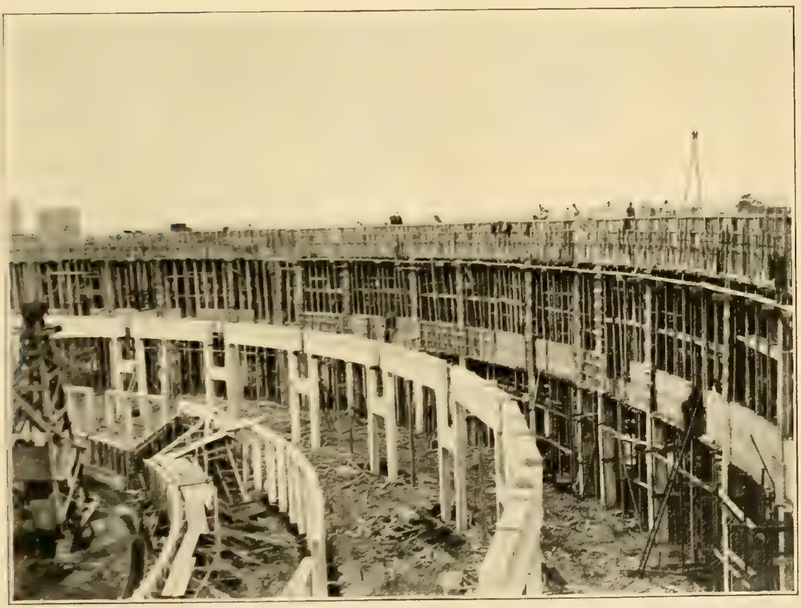

FIG. 4. CENTRAL PART OF CURVE UNDER CONSTRUCTION.

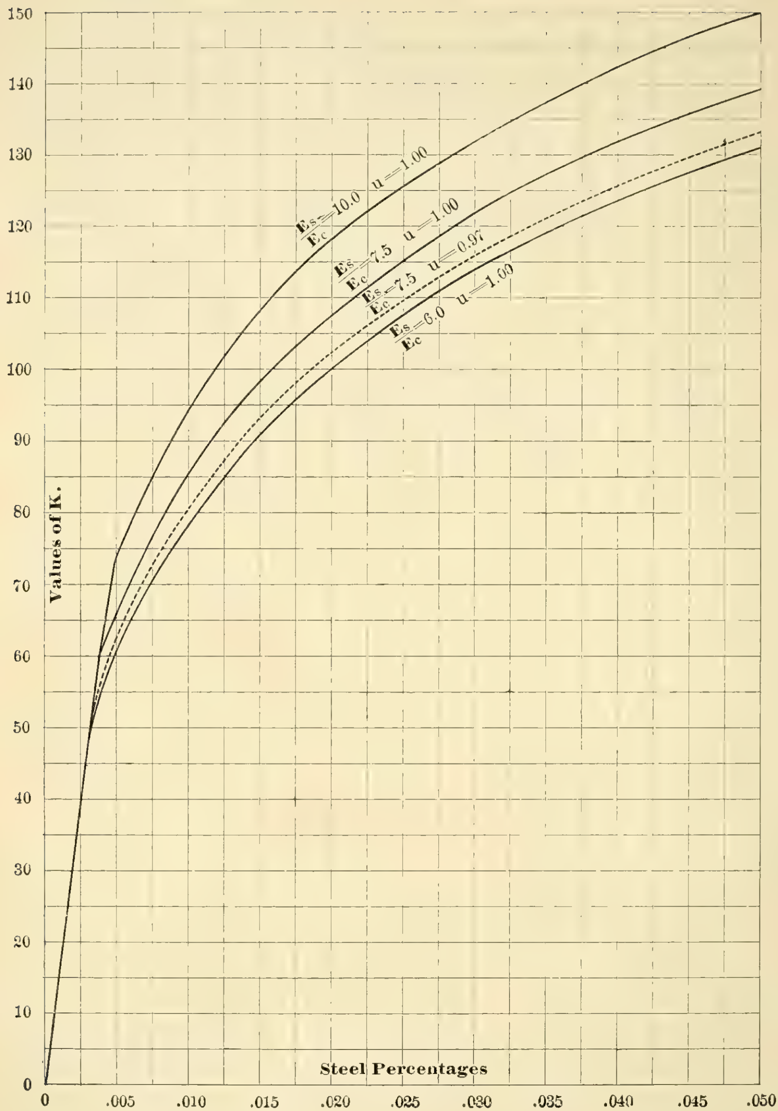

FIG. 5. CURVES SHOWING K'S FOR VARYING $\frac{E_s}{E_c}$ AND u, CONSTITUTING A GRAPHICAL EQUIVALENT OF TABLES I AND II.

ERRATA.

Vol. XXXII, No. 6, June, 1904, page 301.

Line 21. For $K = \frac{2}{3} f_c x \sqrt{1 - \frac{3}{8} x}$,

read $K = \frac{2}{3} f_c x \left(u - \frac{3}{8} x \right)$.

Line 26. For $K = f_c p \left(1 - \frac{3}{8} x \right)$,

read $K = f_c p \left(u - \frac{3}{8} x \right)$.

To make plain the method of figuring with $u = 1.00$, the preceding numerical example will be repeated here.

Assuming steel percentage as before at 0.007, and taking $K = 74$ from Table II, $bh^2 = \frac{M}{K} = \frac{2,000,000}{74} = 27,000$ in.^{3}, and $h = \sqrt{\frac{27,000}{16}} = 41.1$ inches. Adding 2 inches below the steel, the depth becomes 43.1 inches. The amount of steel becomes $0.007 \times 16 \times 41.1 = 4.6$ square inches—a shade less than before.

Fig. 5 shows the K's of Tables I and II plotted with the values of p and K as abscissas and ordinates respectively. Here can be seen the relative effects of changes in u and $\frac{E_s}{E_c}$. It may be observed that with concrete old enough to give the value 6.0 for $\frac{E_s}{E_c}$ it might be permissible to allow a unit compression on the concrete above 500 pounds and diminish the already inconsiderable difference between the K's for the ratios 6.0 and 7.5. The values of K except for the percentages below 0.003 to 0.005 are directly proportional to the allowable unit compression on concrete. The values in the table being for 500 pounds per square inch, K's for other values can be easily computed accordingly.

The value K may be expressed generally for the values of p above 0.003 to 0.005 as follows:

$$K = \frac{2}{3} f_c x \sqrt{1 - \frac{3}{8} x}$$

where f_c is the allowable compressive stress in pounds per square inch on the concrete, and

$$x = -\frac{3}{4} p \frac{E_s}{E_c} + \sqrt{\frac{3}{2} \frac{E_s}{E_c} p \left(u + \frac{3}{8} \frac{E_s}{E_c} p \right)}$$

For the low values of p not covered by the preceding,

$$K = f_s p \left(1 - \frac{3}{8} x \right)$$

where f_s = allowable tensile stress per square inch on the steel,— other letters as before.

The K's are seen to be quasi allowable fiber stresses. Multiplied by the area and length expressed by bh^2 they give a moment of a couple, the resisting couple in the beam, as they should. The K's multiplied by 6 give quantities comparable with the fiber stresses allowed in rectangular wooden beams. It thus appears that a steel-concrete beam is generally considerably inferior in carrying capacity to even a spruce beam of the same breadth and depth.

Before leaving this part of the subject it may be worth while

to point out that Mr. A. L. Johnson's four formulas* for strength of "average rock concrete" may be condensed, using a factor of safety of 4, into $M = 87.5\ bd^2$ with u at 97 per cent., and give for p almost exactly 0.007. According to this method of figuring, the K given in Table I as 70 would correspond to a factor of safety of 5. It seems likely that other formulas for strength of steel-concrete beams might be put into the form $M = Kbh^2$.

TABLE II.

VALUES OF K, FOR VARIOUS PERCENTAGES, p, OF STEEL.

$u = 1.00$; $f_s = 16{,}000$; $f_c = 500$.

$E_s / E_c = 6.0$		$E_s / E_c = 7.5$		$E_s / E_c = 10.0$	
p	K	p	K	p	K
.001	16	.001	15	.001	15
.002	31	.002	30	.002	30
.003	45	.003	45	.003	44
.004	54	.004	60	.004	59
.005	59	.005	65	.005	73
.006	64	.006	69	.006	78
.007	68	.007	74	.007	82
.008	72	.008	78	.008	86
.009	75	.009	81	.009	90
.010	78	.010	84	.010	94
.012	83	.012	90	.012	100
.014	88	.014	96	.014	105
.016	93	.016	100	.016	110
.018	96	.018	104	.018	114
.020	100	.020	107	.020	118
.030	114	.030	122	.030	132
.040	124	.040	132	.040	142
.050	131	.050	139	.050	150

Furthermore, it may be recorded that alternative somewhat simplified forms of Professor Hatt's expression $M = bh^2\ (\frac{5}{12} f_c\ x^2 + p\ f_s\ (u - x)\ )$ for the moment of resistance of a steel-concrete beam ignoring the tensile strength of the concrete are $M = bh^2 \times p\ f_s\ (u - \frac{3}{8}x)$ and $M = bh^2 \times \frac{2}{3}\ f_c\ x\ (u - \frac{3}{8}x)$. The coefficients of bh^2 in these three equations are the K of the preceding. The first one containing both f_c and f_s requires the insertion of consistent values for these two terms, and is hence awkward for use. Either of the last two is free from this difficulty,—working values can be sub-

*_Railroad Gazette_, March 13, 1903, p. 183.

stituted at will for f and c. Of course the one giving the smaller value of M is the one to be used in any case. The values of K tabulated above are, as above explained, the values of these coefficients which will give these decisive values of M.

The foregoing is the basis of determination of the cross-section of the girder and of the steel in the tension flange. The vertical reinforcement was given no less consideration. The recommendation of the French authority Christophe* not to permit beams in which the average vertical unit-shear oversteps 14 to 30 pounds per square inch to go without vertical reinforcement of steel, supported as it was by experiments† by the writer, was adopted.

Accordingly, stirrups or frames made of Ransome rods were used in all girders where the shear exceeded about 20 pounds per square inch. These stirrups were made of two and in some cases three U's (Pl. II), bent and wired together to templet. By being accurately made, they aided in the correct distribution of the lower flange rods. The stirrups so made were put in a plane transverse to the girder (Pl. II), usually vertical, and cross-sectioned and spaced so that at intervals along the beam not exceeding the depth of the beam there was a sufficient cross-section of stirrup to take up in tension enough of the vertical shear to leave a balance which, divided by the gross cross-section of the girder, would amount to not exceeding 25 pounds per square inch. In some of the smaller girders and in critical points in the largest ones the stirrups could take up the whole of the shear without overstepping 16,000 pounds per square inch in the steel. Care was taken in all cases to see that the stirrups had sufficient anchorage above and below the middle of the girder to develop their tensile strength without danger of pulling through the concrete. As a further precaution in this line, the rods at the open ends of the stirrups were bent at right angles (Pl. II). These vertical frames or stirrups suggest the verticals of a Howe truss, the intermediate concrete furnishing the diagonal compression members completing the analogy with such a truss. The analogy is with a double or multiple intersection truss if the stirrups appear at intervals of less than the depth of the girder. Another analogy is with the stiffeners of a plate girder, the stirrups of the concrete girder supplementing deficient tensile strength just as the stiffeners supplement deficient compressive strength. As with stiffeners, the most efficient position, other things being equal, would be at an

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* Christophe: *Le Béton Armé,* 2d Ed., p. 635.

† See Appendix.

inclination of 45 degrees, and, as with stiffeners, there are objections to their being set otherwise than vertical, especially when independent pieces of metal form the flange tension rods.

The steel-concrete beam work included simple girders, 24 feet 9 inches in span, with sections 16 x 47 inches, 18 x 45 inches, 22 x 60 inches (Pl. II), and 24 x 60 inches, and (Pls. III and IV) two systems of curved (radius 190 feet) cantilever girders in row D with sections 18 x 45 inches and 24 x 60 inches respectively. The cantilever system permitted the retention of the same cross-section throughout the curve in this line of girders as was used on the tangent, and to some extent counterbalanced the rotary effect of the curvature of the girder. The ends of cantilevers and of suspended spans being critical points subject to very severe shear, they were stepped so as to reduce the effective concrete area as little as possible and armored with special care. The stirrups used here were of special construction, placed in an inclined position, and were designed to resist the whole vertical shear.

The cantilever ends tend to act as joints at which the shrinkage stresses are relieved. The first suspended span to be built shortened in hardening and slipped on the treads of one of the stepped ends so as to show a crack throughout the extent of the risers of the joint, and in slipping spalled the corners of the steps slightly. After this, four 1-inch rods were put in at mid-height of the girder and lengthwise with it, crossing the joint and extending into both the cantilever end and suspended span far enough to develop the strength of the rods with a view to prevent this slipping, and, so far as seen, the result has been a success. Shrinkage joints are thus kept about 115 feet apart in this line. At the ends of these intervals are opportunities for shrinkage to take place harmlessly. Besides using the rods, the steps were finished off with a troweled surface truly level, so as to leave things in shape for a harmless slip should the rods prove ineffective. It was at one time planned to use two quarter-inch steel plates lubricated with graphite at each of these treads to facilitate sliding and to prevent spalling, but it did not finally seem necessary to go to such a length.

These lines of cantilever girders were subject to a very complex set of loads and were much cut up by promenade floor beams and passageways for stairs. The girders in row C, on the curve (Fig. 3 and Pl. II), were all straight—a series of chords—but they support the ends of trusses and are hence much larger than the girders of the same row on the tangent, their section being 22 x 60 inches as against 16 x 47 inches.

The promenade floors were made of slabs of inverted trough

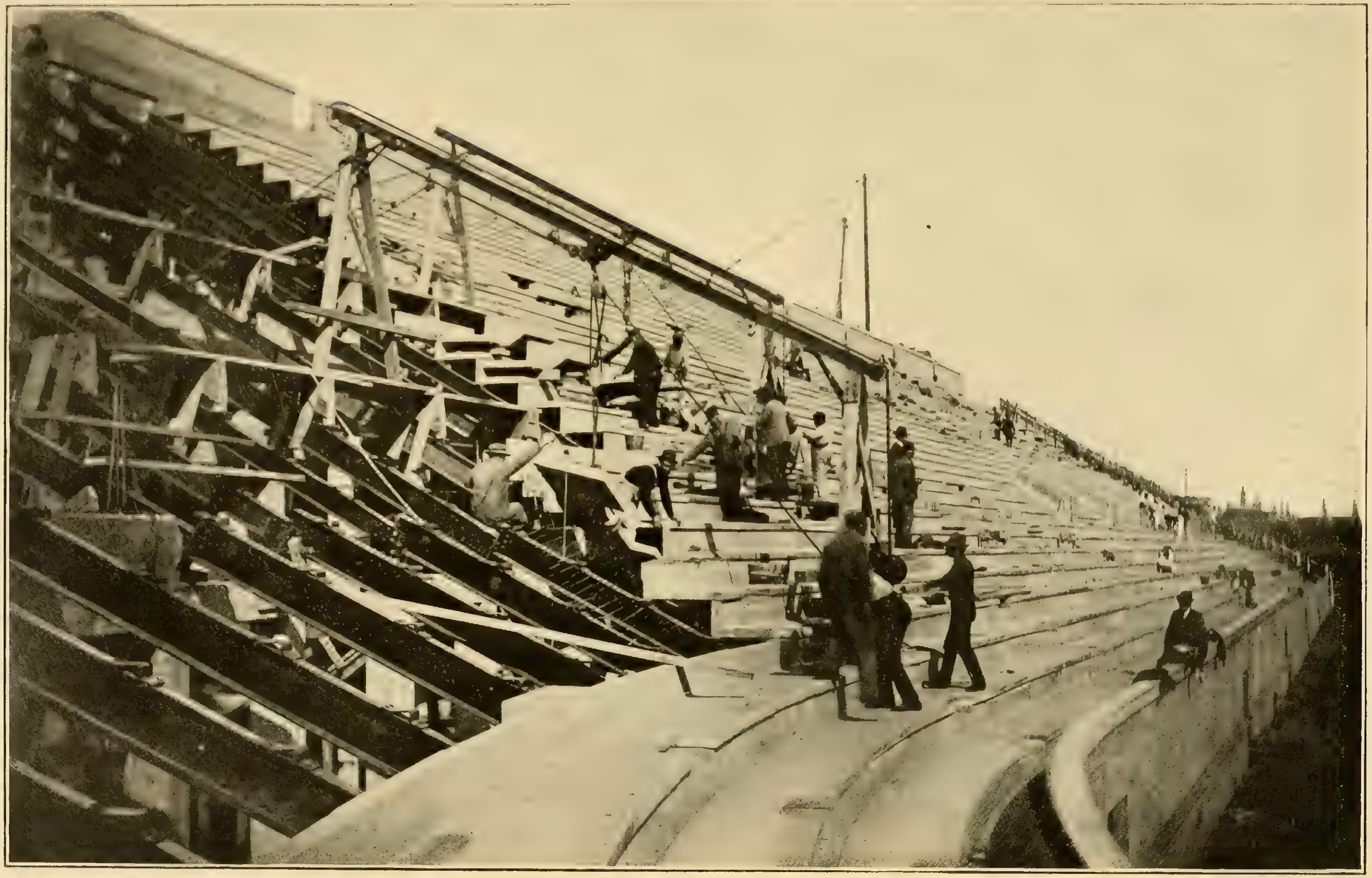

Fig. 6. Setting Seat Slabs on the West Wing.

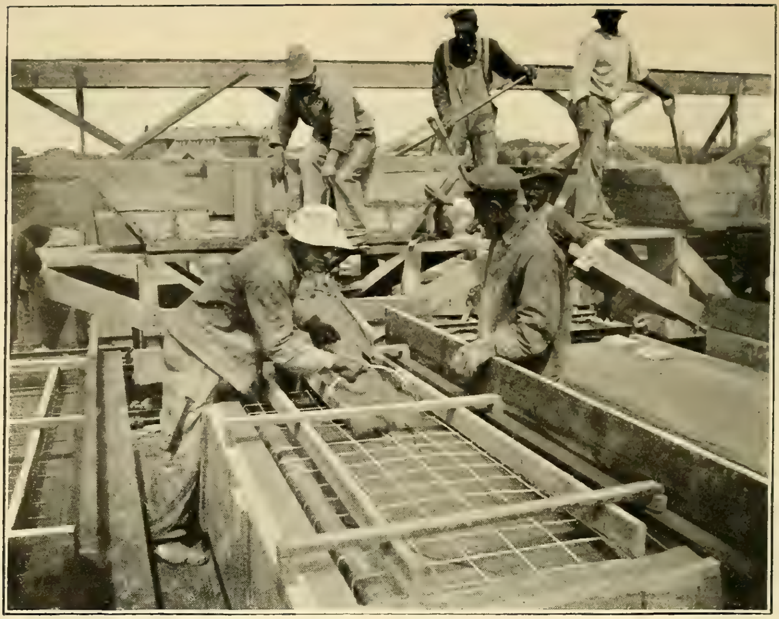

Fig. 7. Casting a Seat Slab.

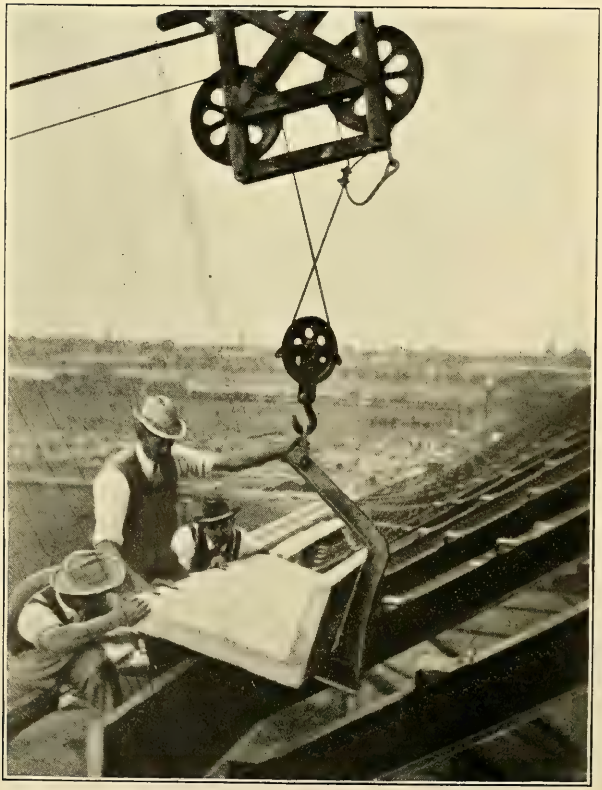

Fig. 8. Method of handling Seat Slabs in Setting.

section (Pls. II, III and IV) about 8 feet 3 inches wide and some 20 feet in span, cast alternately in place, thus providing shrinkage joints at the edge of every slab; the thickness of the body of the slab is $4\frac{1}{2}$ inches, exclusive of the granolithic finish, and the flanges are 6 x 18, making practically a $4\frac{1}{2}$-inch flat floor resting on 12 x 18 joists 8 feet 3 inches on centers and 17 feet in span.

The seat slabs are a series of $\lrcorner$ s set up so as to form a flight of treads and risers (Fig. 6 and Pl. I). They are of crusher-dust concrete (poured at a consistency of cream) reinforced by a half-inch rod at the base of each riser and electrically welded steel wire netting with rectangular mesh furnishing straight wires 0.162 inches in diameter, 5 inches on centers running across the treads and up the risers. The wires running the other way are somewhat smaller and closer together. In the treads this netting furnishes the ordinary tensile reinforcement for the span from riser to riser, besides hanging one edge of the tread to the base of the riser, and in the risers it furnished vertical reinforcement against shear, for the risers constituted a series of joists running from one steel beam to the next, the span being usually 8 feet 3 inches. Fig. 7 is a view of the sand casting process. In the foreground is seen the method of supporting the reinforcement while the mold is filled. At the right is a similar mold filled with hardening concrete.

These slabs were cast in small units of about eight cubic feet each to facilitate handling and to provide amply against shrinkage cracks. They were some 4800 in number, and, including those on the curves, required ninety-five different patterns, counting rights and lefts as alike, and in many cases counting as alike such patterns as varied only slightly in length. On the semicircle they were made curved, but a constant radius was used for all, regardless of their distance from the center. The true radii would have had thirty-one different values, ranging from 115 to 189 feet, but 166 feet 8 inches was chosen as a convenient mean to use for them all.

The handling which all these slabs underwent in storing and placing formed an automatic system of testing, which was considered a distinct advantage of the method of manufacture. They were cast with one-eighth-inch allowance for end joints, but the sand casting proving to be a less accurate process than was expected, more or less picking and clipping had to be resorted to in setting them. An additional and probably more important cause for such modifications was inaccuracy in the steel-setting. Fig. 8 shows in detail the method used for grappling the slabs for hoisting and setting.

The treads of these slabs are an illustration of concrete reinforced with a small percentage of steel and accordingly rated for strength from the point of view of the steel. This strength is ample almost to excess, even with this small allowance of steel, yet thinner sections of concrete were not seriously considered, three and a quarter inches on the average being adjudged a suitable minimum from the point of view of resistance to abrasion, shocks, etc., and the omission of the steel netting altogether was, of course, not seriously entertained—even though the concrete might, by counting on its tensile strength, be figured out as strong enough.

WALLS AND PARAPETS.

The special problem in the design of the walls and parapets which will be considered here is how best to provide for shrinking so as to minimize the evil of cracking from this cause or from temperature changes. One way is frankly to leave joints at short intervals free to open, using steel reinforcements between these joints to compel all the cracking effect to appear, if at all, at the joints left. These joints are supposed to open in tolerably straight, clean cracks, less unsightly than random cracks would be. They are unsightly enough, however, and it is difficult to make the cracks turn out as straight as expected. There is, therefore, a strong incentive to resort to the other method of treatment and attempt to present all cracks from temperature and shrinkage changes by the aid of proper reinforcement with steel. M. Considère's experiments afford a rational basis for expecting success from such a venture, reinforced concrete having been shown by him to be capable of stretching, without showing cracks, to an extent far greater than that of plain concrete. Mr. A. L. Johnson reports* actual success in building a concrete wall 300 feet long, 8 inches thick and exposed on both sides to the weather, without any joints, and with no cracks appearing in the first year, or up to the time of his report

In the outside wall of row E of the Stadium there was nothing else to do but to depend upon steel reinforcements to prevent shrinkage cracks. It was a place where cracks of any kind would be most objectionable. Expansion joints were left at intervals of 16½ feet, as in the front parapet, but they had to be placed over the center of the piers, in spite of its being realized that the friction from the weight of the superimposed mass would probably prevent all sliding, and thus prevent such joints from being effective. The amount of shrinkage to be expected in setting, or cool-

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* *Railroad Gazette*, March 13, 1903, p. 183.

ing to the minimum temperature, was estimated not to exceed about 0.0005 to 0.0006 of the length. Professor Hatt found* that 1:2:4 concrete with 1 per cent. reinforcement would stretch 0.00088 before cracking. Considère and A. L. Johnson lead us to suppose that this stretch may be considerably more. At any rate, the margin seemed sufficient, and as the two faces of the wall in question were only 4 inches thick, 1 per cent. reinforcement was quite feasible—only a half-inch rod every six inches being required —and was adopted (Pl. Vb). Thus far, after several months from the completion of the first of this work, neither crack nor opening of the joints in the whole extent of the two lines of nearly 1400 linear feet each (with one or two insignificant exceptions) has come to the writer's notice. The joints not opening show that the concrete between them must have stretched as expected. The results of the winter's exposure are looked forward to with much interest.

The front parapet was executed upon the principle first mentioned, shrinkage joints being left every 16½ feet, which opened perceptibly immediately upon the hardening of the concrete, and now constitute open joints sometimes a sixteenth of an inch in width, changing as the temperature rises and falls.

The experience with the back wall being reassuring, and the tying together of row D into continuous sections of about 115 feet each causing no harm, it was determined to apply the same principle to the broad expanse of the end walls, which forms the finish at the tips of the U (Figs. 1, 2, and Pl. Va). These walls are some 75 feet long and from 9 to 50 feet high. They are in the main mere curtain walls only 4 inches thick, supported by a series of columns with which they are monolithic. These walls are armored freely with quarter-inch rods—less care being taken to keep the percentage up to 1 per cent. than was observed in the back wall, the smaller area involved being regarded as justification for venturing below the 1 per cent. These walls have now been stripped several weeks, and so far no cracks in them have come to the writer's notice. Fig. 9 shows the centering for one of these end walls, also the mold for one of the row C girders and in the distance many finished seat slabs on the ground ready for hoisting and setting.

It was seen, as the work progressed, that the completion of the Stadium with all the architectural ornaments before the Yale game was out of the question, but work was pushed on the parts essential for carrying the seats, and by the use of temporary wood work instead of concrete slabs on the steel beams of a portion of the

* *Engineering News*, July 17, 1902, p. 55.

structure, the whole seating surface was ready for use some days before the Yale game, and on the day of that game, five months and two days from the setting of the first batterboards, and less than five months from the turning of the first shovelful of earth, the Stadium was occupied comfortably to its full final capacity.

It is expected that the work will be taken up anew in the spring and pushed rapidly to completion. As will be seen by comparing Figs. 1 and 2 and Pl. I, a prominent part of the work still to be done is the construction of the colonnade along the top of row D, and the roof of the top promenade.

APPENDIX.

Fig. 10 shows beams I (and 2), III, VIII and IX after being broken in a series of tests last spring and referred to in the preceding paper as illustrative of the relative behavior of beams with and without vertical reinforcement. Beam I, with only longitudinal reinforcement, was tested in conjunction with a beam (2) of ⌴ section in a way to make it of interest here as showing the curved break, repeated more perfectly in III and partly approximated in VIII. This curve approximates the curve of maximum internal tension with remarkable closeness—a result due, no doubt, to the high degree of homogeneity attained by the very fine and graded aggregate. This curve shows pretty clearly that failure by shear is closely associated with failure by tension of the concrete.

The methods of loading and supporting the last three beams are shown in the figure.

Beams III and VIII failed in the manner shown, with the end shear at 111 and 100 pounds per square inch, respectively. Beam IX at failure in a totally different manner was resisting a shear of 132 pounds per square inch with no signs of failure by tension above the reinforcing rod or shear. Beams VIII and IX differed in no respect save that the latter had vertical reinforcement and the former had not; and both being cast from a mixture of cream-like consistency, it seemed fair to infer from this pair of beams that a shear of 50 to 80 pounds per square inch sometimes spoken of as allowable without reinforcement, in ordinary concrete was higher than it was safe to permit in this structure. It should be noted, moreover, that the first crack in the vertically reinforced beam did not appear till the load was 2540, while in VIII it appeared at 1500. Undoubtedly more experiments should be made along this line, but in lack of such these two beams were taken to indicate the desirability of the reinforcement. The concrete was rich (one part cement to two

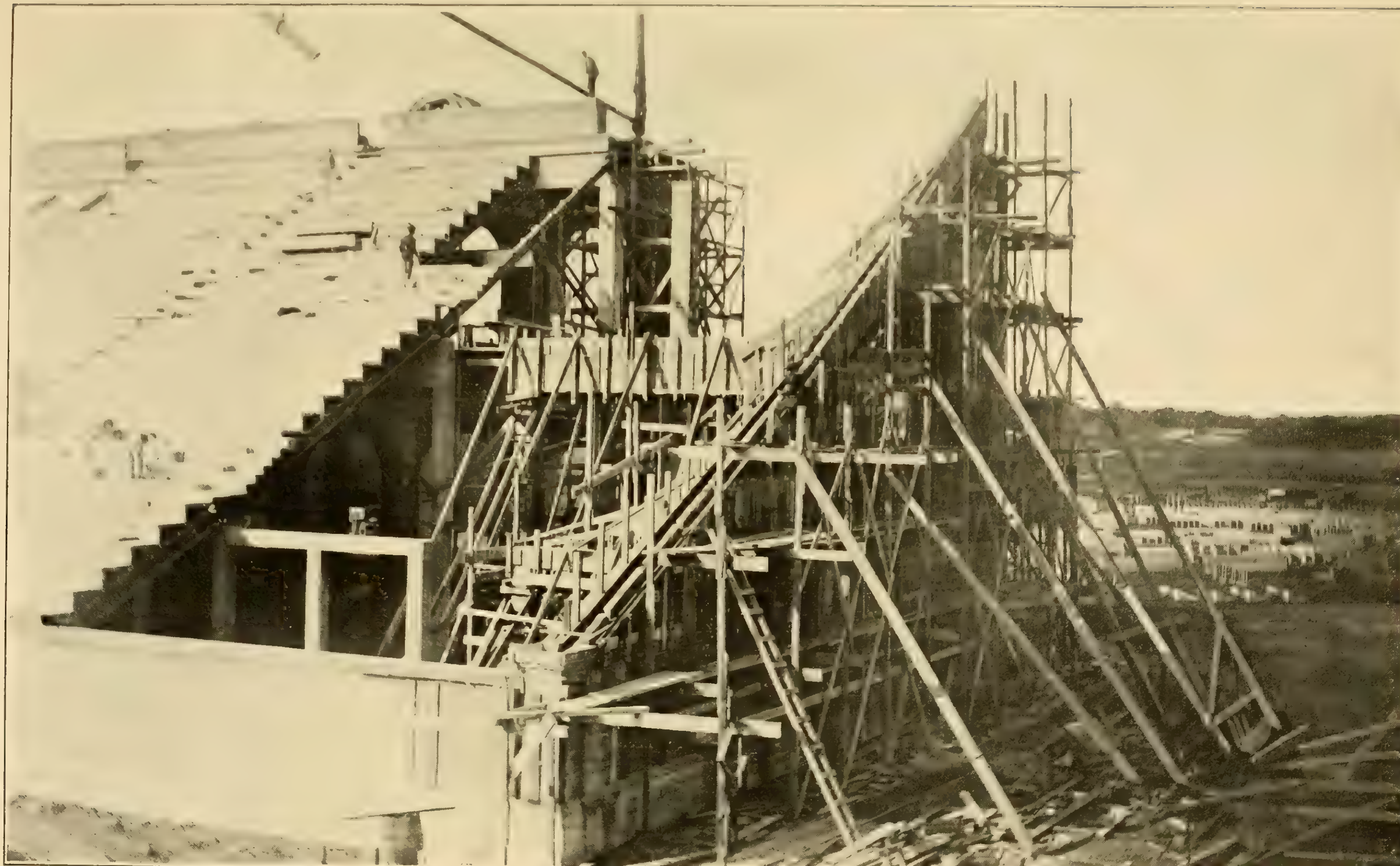
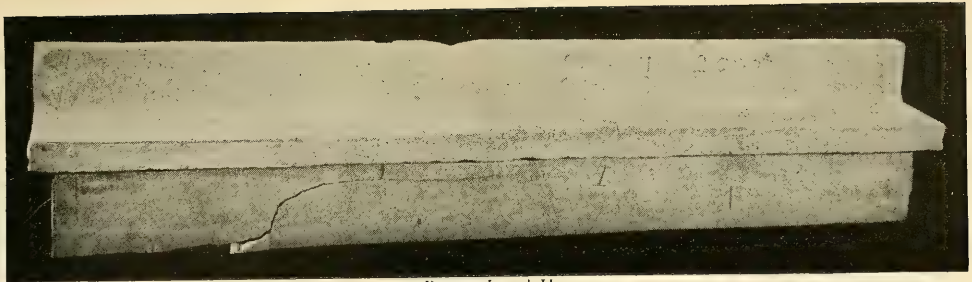
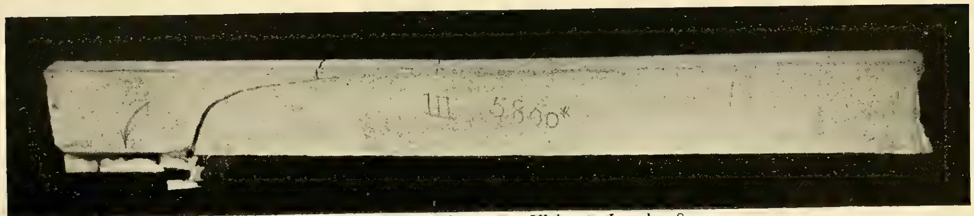


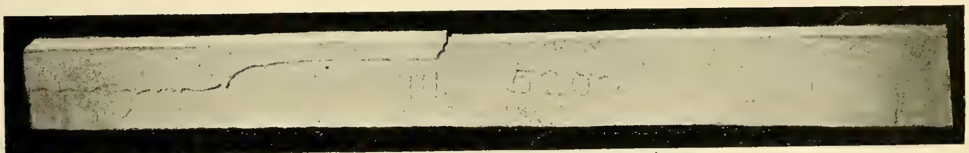
Fig. 9. Forms for End Wall of West Wing of Stadium. In the middle distance Seat Slabs ready for Setting.



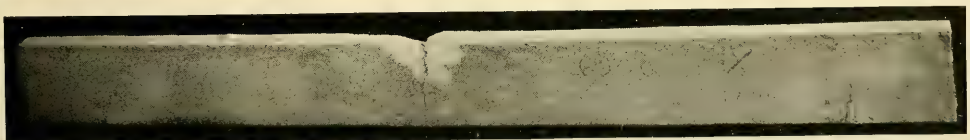
Beams I and II.



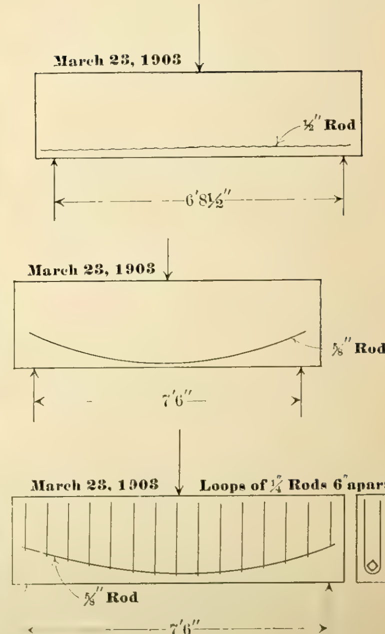
Beam III. First Crack, 1,500. Ultimate Load, 5,800.



Beam VIII. First Crack, 1,500. Ultimate Load, 5,200.



Beam IX. First Crack, 2,540. Ultimate Load, 6,900.



All Beams made of 1 part Saylor's Portland Cement and 2½ parts Roxbury Pudding Stone Dust. January 29, 1903.

FIG. 10. RESULTS OF SOME OF THE BEAM TESTS FOR THE STADIUM.

and one-half parts crusher-dust), of fair age and, being cast from a fluid mixture in a sand mold, there was little likelihood of important variation in the quality of the concrete.

DISCUSSION.*

Prof. Charles L. Norton, Massachusetts Institute of Technology.—Since the publication of Report No. IV of the Insurance Engineering Experiment Station, in which was given an account of some laboratory experiments which showed the great degree of protection afforded structural steel by Portland cement concretes, the experiments have been carried on continuously.

All the early tests which were carried out on perfectly clean steel have now been repeated on specimens in all degrees of initial corrosion, with the same results as shown in the case of the chemically clean steel. Doubt existed in the minds of some engineers as to whether the results as found with clean steel would apply to rusty or dirty steel. The method adopted in the early test was to imbed the specimens in blocks of concrete about 3 x 3 x 8 inches, allow them to set under ordinary conditions and then expose them to changing conditions of warmth, moisture and to carbon dioxide, with traces of sulphurous gases and ammonia. Under these conditions unprotected steel vanished into a streak of rust, but protected by an inch or more of sound Portland cement concrete the clean steel was absolutely unchanged. We can now state further, that this same protection is afforded any ordinary structural steel of that degree of cleanliness likely to be found in use for building.

The origin of many of the specimens was rather obscure, as the more corroded ones were taken from scrap heaps of steel works, many having been exposed to the weather for several years. Some had been in buildings as part of the structure, some in salt water, some in fresh water, some in damp ground and the rest exposed to air under various conditions of dampness. The degree of rust on the specimens varied greatly, from a light yellowish stain to a scale more than $\frac{1}{4}$ inch in thickness.

The specimens were first cut to a size such that their length was not far from 3 inches and their width about 1 inch. They were of all thicknesses from $\frac{1}{50}$ inch to $1\frac{1}{4}$ inches. Some were cut dry, some in water, some with the mill fed with oil, and some of those cut with oil were cleaned with gasoline and others with alkaline solutions, while a third part was left more or less oily. It was

* Manuscript received April 1, 1904.—Secretary, Ass'n of Eng. Socs.

intended that the specimens should include everything met with in regular practice.

Each specimen was stamped and the blows of the steel stamp were sufficient to loosen any rust or scale that was not firmly attached, and a vigorous brushing with a soft wire brush removed any loose dust. Each piece was next weighed, and then calipered at several points, and incorporated in a block, or brick, of concrete, sufficiently large to cover it everywhere to a depth of 1½ inches. The mixture was one part cement, two and one-half parts sand and five parts broken stone in some cases, and one part cement, three parts sand and six parts cinders in others. The cements used were Alpha, Lehigh and Alsen, and care was taken in selecting the sand and stone. The latter was of such size as to pass a 1-inch mesh. The concretes were allowed to set twenty-four hours in air and seven days in water, and were then divided into three groups, one being set out-of-doors, one stored in a damp and odorous basement underground and the third being treated in the "corroders" or steam and carbon dioxide tanks. These galvanized iron tanks were supplied intermittently with steam, hot water, moist air, dry air and quite continuously with carbon dioxide for periods of from one to three months. There were a number of specimens which were further exposed in tide water, in sewers, over furnaces, with constant contact of furnace gases.

After varying lapses of time from one to three months for the specimens in the "corroders," and from one to nine for the others, the specimens were broken out of the briquettes, cleaned by brushing and weighed and calipered. Not one specimen had shown any sensible change in weight or dimension, except where the concrete had been poorly applied. Some specimens were purposely bedded in very dry concrete, and some in concrete partly set, and many of these were not well covered and the steel was seriously attacked where there were voids or cracks. Of the hundreds of specimens of rusty steel examined not one which had a continuous, unbroken coating of concrete gained or lost anything in volume or weight by treatment which caused the practical destruction of some of the unprotected specimens. If loss by corrosion as great as $\frac{1}{1000}$ of the loss occurring with the unprotected specimens had been experienced in the case of the protected pieces it would have readily been noted.

It would therefore seem that if we admit that from a severe trial of a short duration we may judge relatively of the effects of the less severe but longer test of time, it cannot be questioned that structural steel is safe from corrosion if incased in a sound sheet of good concrete, at least for a period of years so long as to make the

subject of more interest to our great-grandchildren's children than to us. We know that bare steel does not rust and fall down over night, and that much of the steel standing has been bare of everything that could protect it, for long years, and it seems to me beyond question that steel properly covered in concrete may well be expected to last far longer than the changes in our cities will allow any building to remain.

There is one limitation to the whole question, that is the possibility of getting the steel properly incased in concrete. Many engineers will have nothing to do with concrete because of the difficulty in getting "sound" work. This is especially true of cinder-concrete, where the porous nature of the cinders has led to much dry concrete and many voids and much corrosion. I feel that nothing in this whole subject has been more misunderstood than the action of cinder-concrete. We usually hear that it contains much sulphur and this causes corrosion. Sulphur might, if present, were it not for the presence of the strongly alkaline cement; but with that present the corrosion of steel by the sulphur of cinders in a sound Portland concrete is the veriest myth, and as a matter of fact the ordinary cinders, classed as steam cinders, contain only a very small amount of sulphur. There can be no question that cinder-concrete has rusted great quantities of steel, not because of its sulphur, but because it was mixed too dry, through the action of the cinders in absorbing moisture, and that it contained, therefore, voids; and, secondly, because in addition the cinders often contain oxide of iron which, when not coated over with the cement by thorough wet mixing, causes the rusting of any steel which it touches.

There is one cure and only one, mix wet and mix well. With this precaution I would trust cinder-concrete quite as quickly as stone-concrete in the matter of corrosion. It has been suggested that steel which has been rusted to a slight depth becomes protected by this coating from further rusting. Nothing could be further from the truth. A large number of specimens were rusted by repeated alternate wetting and drying to see if they finally reached a constant condition. Instead of doing this, they all showed an irregular but persistent loss in weight, on further rusting, until some had practically been washed away.

The increasing use of steel of small dimension in floors and roofs, twisted rods, expanded metal, etc., has caused some question as to the advisability of their use in view of the possible great effects of corrosion, as compared with the effects of corrosion on larger members, but with sound concrete of a thickness of about 1½

inches between the steel and the weather I do not question the durability of these lighter members.

The destruction caused to steelwork by rust is certainly not more appalling in most instances, at least, than that caused by electrolysis. The action here is more apt to be local, and hence more dangerous, in that inspection or protection of other parts of a structure will not indicate or prevent impending disaster to the one member which may serve as the point of departure of the escaping electric current. No satisfactory treatment other than some sort of waterproofing has appeared to be successful, and study of this matter is going on at present in many places. It is a problem for the chemist rather than for the engineer.

The next step in this research is to find out in the same general way the degree of protection afforded by paint, and, second, by brick and tile work. This is now under way, and the rapidity with which the "corroders" destroy some paints is such that a report on this subject may be looked for in the near future.

The investigation of the relative efficiency of different paints as a protective coating for structural steel being now under way, it is desired that all kinds of paint be submitted to our test of exposure to varying conditions. To this end we invite all dealers and manufacturers of paint, for this purpose, to send samples to the amount of 1 gallon to Prof. C. L. Norton, Room 4, Walker Building, Massachusetts Institute of Technology, with any directions for applying the paints to either clean or ordinarily rusty steel. The results of these tests will not be published without the consent of the persons submitting the paint to test.

Some pieces of steel will, after coating with the paint under test, be submitted to various corrosive influences; and the details of the exposure being such as will correspond in nature to the actual exposure of structural steel, but of an intensified degree, it is believed that relative results may be arrived at in a reasonably short time in this way.

PROF. GAETANO LANZA.—I have been asked to tell you about some experiments upon reinforced concrete beams and columns, made by some of my students at the Massachusetts Institute of Technology, for their graduating theses; and notwithstanding the fact that an account of these experiments has been published in a recent number of the *Transactions of the American Society of Civil Engineers,** it has still been thought worth while to have the story told here again.

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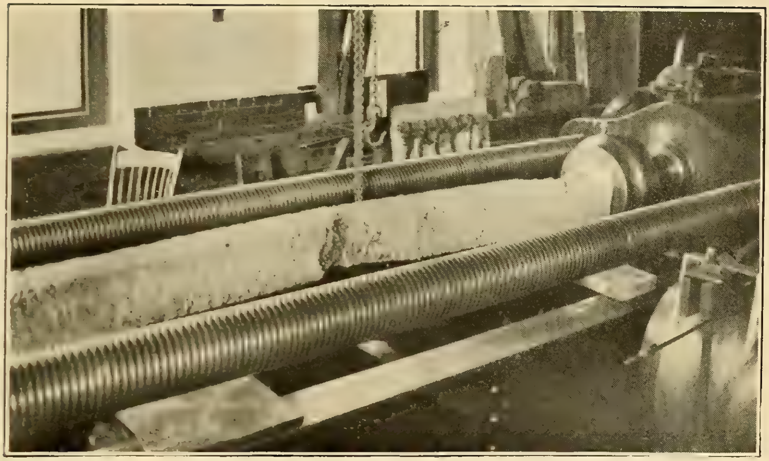
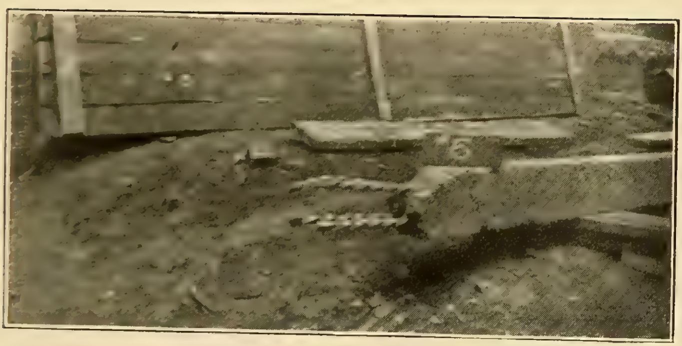
* Vol. L, pages 483 to 485, in discussion of a paper by Myron S. Falk, entitled "Notes on the Coefficient of Elasticity of Concrete and Mortar Beams During Flexure."



Beam No. 3.



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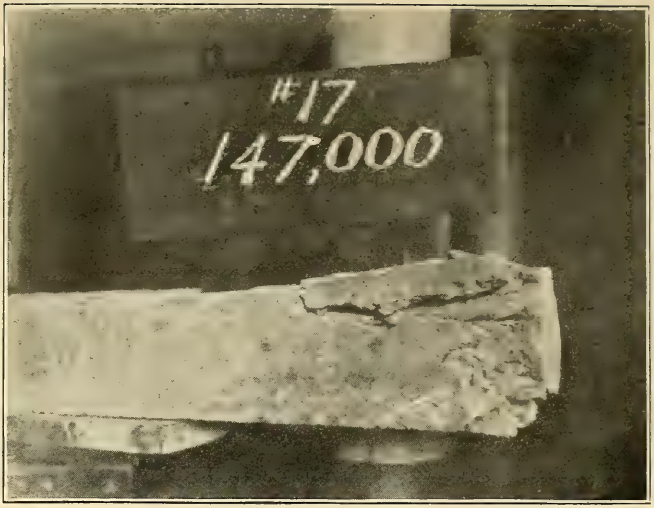

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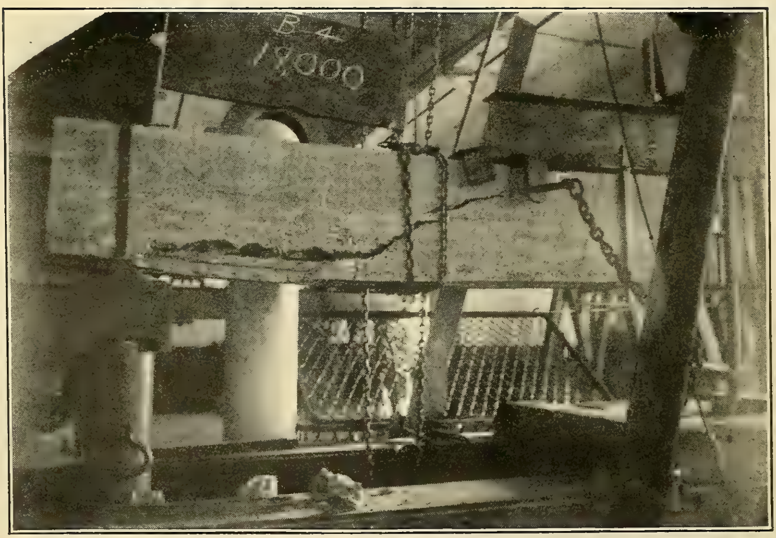
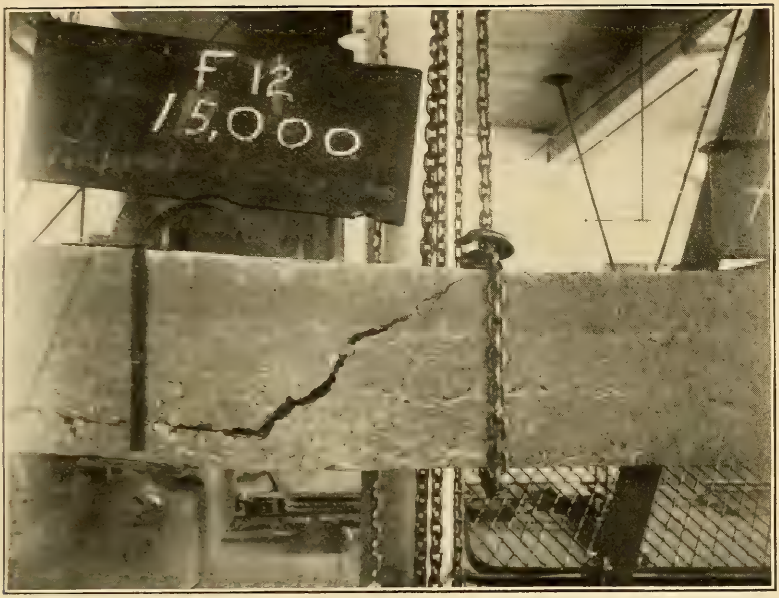
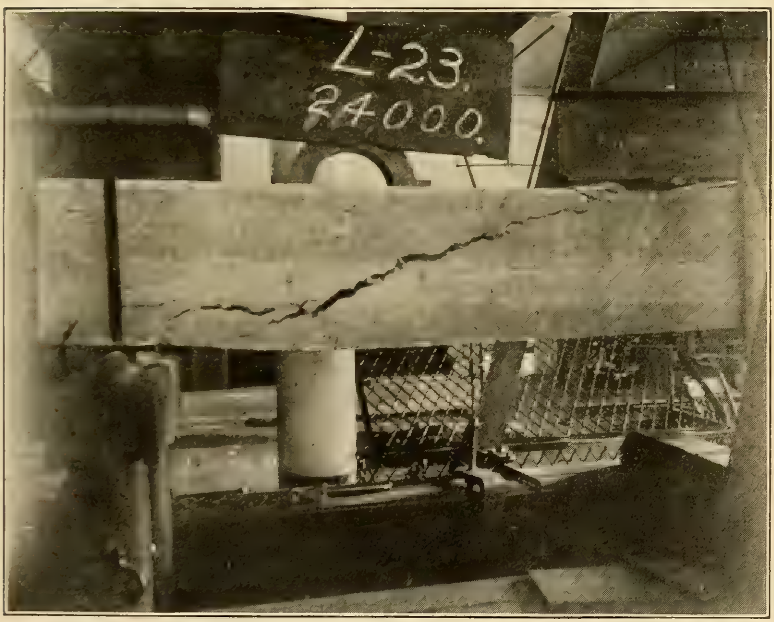


Beam No. 18.



BEAM NO. 25.



BEAM NO. 26.

The following is a list of the specimens tested, viz: One plain concrete beam, 8 x 12 inches x 11 feet span. Twenty-six reinforced concrete beams, 8 x 12 inches x 11 feet span. Fourteen reinforced concrete columns, 8 x 8 inches, of which four were 6 feet long, four 12 feet long and four 17 feet feet long. Seven reinforced concrete columns, 10 x 10 inches, of which two were 6 feet long, four 12 feet long and one 17 feet long. Seven plain concrete columns, 8 x 8 inches and 5 feet long. The concrete was made of one part by volume of Portland cement (Star brand), three parts by volume of sharp, clean and coarse sand from Newburyport, Mass., four parts by volume of trap rock from Somerville, Mass., which would pass a 1-inch ring sieve and two parts by volume of the same kind of rock which would pass a $\frac{1}{2}$-inch ring sieve; the quantity of water used was from 6 to $7\frac{1}{2}$ per cent. by weight. The steel used had a tensile strength varying from 56,000 to 63,000 pounds per square inch, and when twisted about one-third more.

Before planning the series of columns I read carefully the work of Mr. Considère, who, in his Beton fretté, used light vertical rods, $\frac{3}{8}$ of an inch or less square, placed near the outside of the columns, the entire set of vertical rods being surrounded by a wire wound in spiral form and extending throughout the length of the column. The buckling of the vertical rods seemed to furnish the greatest difficulty in his case, and such a result would naturally be expected, in view of the facts stated above.

It seemed better, therefore, to plan this series differently, no spiral reinforcement being used in any of the columns; and accordingly, some of them were built with one reinforcing rod, placed in the center of the section, and others with four rods, placed, respectively, at the middle points of the four half diagonals of the section. The rods in the 8 x 8-inch columns terminated $\frac{1}{2}$ inch from each end of the column, while in the case of the 10 x 10-inch columns the ends of these rods were flush with the ends of the columns. The table of results follows:

Reinforced Columns.										
Number.	Distinguishing Mark.	Age, in Days.	Area of Section, in sq. inches.	Length in Feet.	Number of Rods.	Side of Square Rod in inches.	Plain P, or Twisted T.	Actual Breaking Load in lbs.	Value of P in Formula: $P = f(A_1 + rA_2)$*	Manner of Failure.
1	1	30	64	17	1	1	P.	107,000	125,000	Crushed at end.
2	2	30	64	17	1	1	T.	127,000	125,000	Buckled first, then crushed at end.
3	7	29	64	12	1	1	P.	100,000	125,000	Buckled first, then crushed at end.
4	8	28	64	12	1	1	T.	126,000	125,000	Crushed at end. Poorly made. Crushed portion cut off; the rest bore 156,000 lbs. at 40 days.
5	9	32	64	6	1	1	P.	138,000	125,000	Crushed at middle, then sheared off along the rod to the end.
6	10	31	64	6	1	1	T.	133,000	125,000	Crushed at end.
7	3	31	64	17	1	1¼	P.	136,000	132,000	Crushed at end, shearing obliquely.
8	4	35	64	17	1	1¼	T.	154,000	132,000	Crushed at end, breaking off 3 feet.
9	5	35	64	17	4	¾	P.	182,000	140,000	Crushed at end.
10	6	34	64	17	4	¾	T.	167,000	140,000	Crushed at end; concrete rather poor and rough at that end.
11	17	31	64	12	4	¾	T.	147,000	140,000	Crushed and split open at end.
12	18	32	64	12	4	¾	P.	153,000	140,000	Crushed and split open at end.
13	15	29	64	6	4	1	T.	158,000	162,000	Crushed and split open at end.
14	16	31	64	6	4	1	P.	244,000	162,000	Crushed at end.
15	25	35	100	17	1	1	P.	215,000	188,000	Broke off clean for 3 or 4 feet at end.
16	26	35	100	6	1	1	P.	200,000	188,000	Sheared diagonally at end.
17	42	45	100	6	1	1	T.	228,000	188,000	Sheared diagonally at end, and broke back for half the length.
18	35	31	100	12	1	1¼	T.	262,000	194,500	Sheared diagonally near end.
19	36	29	100	12	1	1¼	P.	257,000	194,500	Crushed at end.
20	33	28	100	12	4	¾	T.	300,000*	203,000	Did not break; exceeded capacity of machine.
21	34	29	100	12	4	¾	P.	274,000	203,000	Crushed at end. Wedge-shaped piece forced in between rods.

*This is not the breaking load.

If we let

P = total load on the column,

A_1 = area of section of concrete,

A_2 = area of section of steel,

E_1 = modulus of elasticity of the concrete,

E_2 = modulus of elasticity of the steel,

$r = \frac{E_2}{E_1}$,

f = stress per square inch in the concrete,

then is the formula $P = f\,(A_1 + rA_2)$ deduced upon the assumption that the stress per square inch coming on the steel bears to the stress per square inch coming on the concrete the same ratio as the modulus of elasticity of the steel bears to the modulus of elasticity of the concrete, which ratio was, in this case, 8.23.

The formula is, of course, true only when the load is such as does not strain any portion beyond the elastic limit. Inasmuch, however, as it has been employed, more or less, to compute the breaking load, by using for f the crushing strength per square inch of the concrete, the values of P have been computed from this formula, using $E_2 = 28{,}000{,}000$, $E_1 = 3{,}400{,}000$ and $f = 1750$ pounds per square inch, in order that the reader may be able to compare them with the actual breaking loads. A perusal of the results will make it evident that a part of the load is borne by the steel and a part by the concrete.

The manner of failure was, generally, crushing at the ends, only two having failed by buckling, one of which was 12 feet long and one 17 feet long. Sometimes the ends sheared diagonally.

The fractures of Nos. 3, 10 and 11 are shown in the cuts.

In the case of the beams, the steel rods extended longitudinally throughout their lengths, those in the lower part having the centers of their cross-sections at the ends of the beams, 2 inches from the bottom, with a sag at the middle from $\frac{1}{8}$ to $\frac{3}{16}$ inch, except in beams Nos. 12, 13 and 14, where the lower rods were $2\frac{1}{2}$ inches from the bottom, at the ends, with a sag of from $\frac{3}{8}$ to $\frac{1}{2}$ inch. In beams Nos. 12 and 13 there were, on each side of the middle, eight pieces of $\frac{1}{4}$-inch twisted wire bent in the $\sqcup$ form inclosing the rods. In beam No. 12 these $\sqcup$ shaped pieces were inclined at 45 degrees to the depth of the beam, whereas in beam No. 13 they were vertical. In beam No. 14 the wire pieces were in the form of a rectangle inclosing all four rods.

Beams Nos. 26 and 27 each contained, in addition to their reinforcing rods, a vertical layer of expanded metal, extending throughout their length and height.

The tests of these five beams were made at the suggestion of Mr. L. C. Wason, for the purpose of studying the effect of these different arrangements upon the apparent tendency of the beams to break by longitudinal shearing. See table of results on following page.

All the fractures except Nos. 1, 2, 3, 4, 19, 20 and 21 were of the following general character, viz: a longitudinal shearing break, at, or a little above, the reinforcing bar, and, in addition, a break extending diagonally (often at an inclination of about 45 degrees) upward toward the center. The point where this diagonal break joined the top of the beam was sometimes at the point of application of the load and sometimes near it.

The fractures of Nos. 18, 25 and 26 are shown in the cuts.

I do not intend to discuss the various methods proposed for calculating the strength of such beams, and it seems to me that before we can feel sure of the assumptions made in deducing them we need to prove or disprove them experimentally.

While I have been interested in hearing Professor Johnson describe the methods pursued by him, *i. e.,* those of Professor Hatt, I will only say that while Professor Hatt claims that the modulus of elasticity for tension of concrete is one-half that for compression, more conclusive experiments will be necessary before I can feel sure of the correctness of this conclusion.

Indeed, the determination of the modulus of elasticity of concrete in tension presents a great deal of difficulty, but it forms a most important factor in any determination of the proper mode of calculating the strength of such beams.

Many methods are proposed by different people for inserting steel pieces in such a way as to prevent the kind of fracture most common in such beams and which has been already described.

Of the methods tried in these series of beams none seems to have prevented the above-stated method of fracture, and hence I feel very doubtful about accepting any proposed method as effective unless it has been proved to be so by experiments made on a full-size scale.

It should be added that the planning of the series and the work of testing and figuring up the results was performed, under the writer's direction, by the following gentlemen for their graduating theses, viz: Mr. Edward Seaver, '01, on beams; Messrs. G. M. Harris and G. B. Wood, '03, on columns, and Messrs. W. H. Adams and I. F. Atwood, '03, on beams. Moreover, these series of tests were rendered possible through the kindness of Mr. L. C. Wason, '91, President of the Aberthaw Construction Company, who furnished all the materials and built all the specimens.

BEAMS.

Number of Beam.	Age, in Days.	Number, Size and Kind of Bars near Bottom. Number.	Side of, sq. Inches.	Plain P or Twisted T.	Number, Size and Kind of Bars near Top. Number.	Side of, sq. Inches.	Plain P or Twisted T.	Manner of Loading at Time of Fracture.	Weight of Beam, in Pounds.	Breaking Load, exclusive of Weight of Beam, in Pounds	Maximum Bending Moment at Fracture, in Inch-Pounds.	REMARKS.
1	40	.....	......	......	.....	......	......	Center.	1,198	1,302	62,733	Vertical break near middle of span.
2	40	1	1/4	T.	.....	......	......	"	1,200	1,300	62,700	Vertical break at middle. Bar drew down to 1/8 inch and broke.
3	30	1	1/2	T.	.....	......	......	At two points.	1,205	10,095	241,973	Vertical break at one point of application of load. Bar drew down to 1/4 inch and broke.
4	38	1	3/4	T.	.....	......	......	Center.	1,160	13,680	470,580	Concrete crushed on top.
5	50	1	7/8	T.	.....	......	......	"	1,290	14,710	506,715	
6	50	1	1	T.	.....	......	......	"	1,204	15,796	541,134	
7	41	1	1 1/4	T.	.....	......	......	"	1,195	12,805	442,283	
8	41	2	1	T	.....	......	......	"	1,240	18,760	639,540	
9	42	2	1 1/4	T.	.....	......	......	"	1,274	23,105	783,486	
10	42	2	1 1/4	T.	1	1/2	T.	"	1,279	21,105	717,569	
11	45	2	1 1/4	T.	2	3/4	T.	"	1,294	23,105	783,816	
12	30	2	1 1/4	T.	.....	......	......	At two points.	1,282	24,200	553,553	
13	31	2	1 1/4	T.	.....	......	......	" "	1,292	29,200	663,718	
14	30	2	1 1/4	T.	2	3/4	T.	" "	1,341	24,200	554,527	
15	53	1	1	P.	.....	......	......	" "	1,292	15,250	356,818	
16	49	1	1	T.	.....	......	......	" "	1,211	16,500	382,982	
17	43	2	3/4	P.	.....	......	......	" "	1,271	15,950	371,872	
18	40	2	3/4	T.	.....	......	......	" "	1,200	19,000	437,800	
19	35	4	1/2	P.	.....	......	......	" "	1,261	17,500	378,065	Beam had a crack about 18 inches from center. Failed at this vertical crack.
20	33	4	1/2	T.	.....	......	......	" "	1,213	20,000	433,329	Failed by longitudinal shearing.
21	57	1	1 1/4	P.	.....	......	......	" "	1,213	12,500	295,015	Vertical break at one point of application of load. Rod pulled through. Concrete was not sufficiently packed in making.
22	54	2	7/8	T.	.....	......	......	" "	1,248	22,250	510,092	
23	57	2	7/8	P.	.....	......	......	" "	1,221	20,250	465,647	Beam cracked, in handling, 22 inches from center. Failed by longitudinal shearing.
24	47	4	5/8	T.	.....	......	......	" "	1,203	19,250	443,350	
25	50	4	5/8	P.	.....	......	......	" "	1,192	15,250	355,168	
26	40	2	3/4	T.	.....	......	......	" "	1,215	24,250	553,548	
27	49	1	1	T.	.....	......	......	" "	1,222	21,750	498,663	

Prof. Arthur W. French, Worcester Polytechnic Institute.—In planning a concrete-steel building, before reaching the details, careful consideration of the peculiarities of concrete-steel combinations may well decide many important features in the layout of walls, columns and beams.

With the available space below the seats of the Stadium, it may be a question whether the girders of 24 feet 9 inches span, carrying heavy concentrated loads, might economically have been replaced by shorter spans and a greater number of columns.

I can but feel a bit of regret that such a monumental structure was not planned to avoid all exposed structural steel, and that reinforced concrete, which forms so large a part of the Stadium, was not used exclusively.

The first thing that strikes one as peculiar in the construction of concrete work is the fact that the structure cannot be built as a monolith; that it is cut up, as Professor Johnson has shown—cut up into sections to provide for expansion and for possible cracks. This leads to many complications. The day's work is stopped at places where, on the plans, it would look as though filling up with concrete might go on; the day's work at certain points is limited, and the work must be spread over considerable areas. If we dared to build such structures without joints it would greatly simplify the matter.

The spacing of the steel in the columns offers some difficulties, especially with the hoops. The four rods in the corners of the columns, without the hoops, are very easy to keep in place, and to keep exactly at the right distance from the corner.

The minute the hoops are introduced we must have a free chance, from the top to the bottom, to drop the hoop over the four corner rods, and it was with some fear of having them show through the concrete that I placed them as shown. However, I think none of them have shown through. The packing of the steel in the beams has been well illustrated; and the introduction of stay rods, for the purpose of taking up the shearing, adds to the difficulties of placing the concrete.

One feature of the concreting, very pleasing to me, was the agreement, between Professor Johnson and the Aberthaw Company, as to the consistency of the concrete. Being a firm believer in wet concrete, I was delighted to have a chance to use it.

Those columns, 14, 16 and 24 inches square and 25 feet in height, we found it would be impracticable to fill, except from one stage at the top. If that concrete had been put in dry, or of the consistency advocated by some in the past, it would have been diffi-

cult to produce smooth or solid work. It was put in wet enough to spade easily into place, the spades being worked continuously, usually by two men. I think those of you who have seen the work have noticed that it shows full, without voids. Experiments show that it is equally solid throughout.

As to the effect of consistency upon the strength of the concrete, there may be a difference of opinion. I believe that, after a lapse of time, it will compare favorably with any drier mixture.

The work at the Stadium was a summer's vacation for me, and one leading to very pleasant connections with the supervisors and those in charge at Harvard. My particular interest was in the study how to place that work. The plan adopted was, I think, fairly satisfactory, as shown by the time taken to bring the work to such a state of completion that it could be used. The structure is 50 to 60 feet in height, and has various heights. Except the 16-foot promenades there were no level landings upon which to place derricks, and the first question was to design the handling plant. We adopted towers and cableways, as you noticed on the slides. They have their limitations, but, on the whole, were fairly satisfactory. The towers were rolled along on tracks and placed wherever the cables could be used to the best advantage. The casting floor of the foundry was served with cranes and railroad tracks, as was clearly shown.

The subject of concreting with steel reinforcement may be made too complicated, so far as theory goes. I am perhaps not competent to judge, but it seems to me the design of the section of a beam will be changed. The variations in the modulus of elasticity in concrete prohibits any fine computation of sections, and I believe it will be, as Professor Johnson has shown, so simplified that any engineer will pick out his concrete-steel beams with something of the confidence he feels in choosing timber, and with similar limitations.

I think there is nothing further I can now add to the discussion. I am glad to acknowledge my indebtedness to the Society and to Professor Johnson for a chance to hear the paper.

Prof. George F. Swain.—We are very much indebted to Professor Johnson for this paper, and I hope it will be published entire, for it contains a great deal of information which is valuable to those who have to do with structures of reinforced concrete.

The matter of shearing in concrete is of much importance, and I wish Professor Johnson had explained a little more in detail how he proportioned his stirrups. As he suggests the analogy between them and the verticals of a truss, I should be glad to know whether

he computed them by taking the longitudinal shear at the neutral axis along a distance equal to the distance between stirrups, deducted from this what the concrete itself would carry, allowing 20 pounds per square inch shearing stress, and then multiplied the difference by the ratio of depth of stirrup to distance between stirrups. The stiffeners in a plate girder might be computed in this manner, though I do not know of this method having ever been followed in design. Indeed, the action of the stirrups, like that of plate-girder stiffeners, must be very uncertain, and the stirrups probably act partly in tension, and to some extent in shearing also. With reference to the shearing strength of the concrete, I note in *Beton und Eisen* for 1903 (Heft II) a rather elaborate discussion of the subject.

With reference to the protection of steel by concrete, foreign authorities claim, as is well known, that rusty steel or iron, if covered with concrete, will lose its rust and become bright. I should like to ask Professor Norton whether he has any experiments which substantiate this. In the East Boston tunnel the steel rods used were cleaned by the sand blast, it being considered best to be on the safe side. Perhaps this precaution was unnecessary.

Professor Norton.—In answer to Professor Swain's question, I would say that, paradoxical as it may seem, with quite a number of specimens, which were coated with what would be called rust (not oxide, but rather hydrate of iron), or rather the beginning of rust, we found the specimens were cleaner after the experiment than before, and that they weighed a little less than when the concrete was put on. The action is small, because we had taken every precaution to treat them as harshly as possible. The weighings were made as carefully as could be done. I have been very chary about making statements on that point. The evidence certainly points to a real formation, on some of the heavier specimens of iron, free of iron hydrate or iron oxide. Whether this formation is of any use or not I do not know. It looks like a black smouch on the iron itself rather than a return to the structural material.

I had commenced to make one hundred or more slabs of cinder- and stone-concrete for one of the construction companies. The results of that investigation not being complete, we have not yet been able to publish it, but one of the things we did find out was that mixing the concrete just as wet as we could mix it, so wet that we had to put waxed paper on the bottom and sides of the mold, and then mixing it just as dry as we could mix it and tamping from above, so that the mixture was solid—that is, well together,—the one was gelatinous; you could have run a shovel in and cut a groove

in it and it would return to its position; while the other was of such rigidity that if you stepped on it the imprint of your heel would remain in it; all were made and the slabs were broken. In the meantime we weighed some of the smaller pieces. We could not find out by breaking or weighing which was mixed wet and which was mixed dry. In breakage, the difference between wet and dry was less than 5 per cent., which was less than would be expected. Some were cinder-concrete and some were stone-concrete. They were of different thicknesses: 2, 2½, 3 inches, etc., to 8 inches, and the sizes of the slabs from 2 x 3 feet to 8 x 10 feet.

Moisture in the mixture seems to aid in making a first-class bond between the concrete and the steel. The metal was imbedded within an inch of the lower surface. Every one of the slabs carried a certain definite load, up to the point of developing a tension crack. The cracks give very ample warning. Some deflected 6 inches before they broke, a very interesting point in view of the question of safety to viewpoints of a building.

We are having a good deal of steel-concrete with corner-tension rods of steel, a most excellent place to put it, from the point of view of strength, but a poor place in case of fire. I have known a concrete structure, built for testing purposes by Professor Lanza and myself, having 1 inch of concrete between the steel and the fire. Then we put it through the New York fire test. It stood it for 3 hours and 40 minutes, and then the posts gradually weakened. The concrete softened and the iron began to pull through. Finally, when the concrete was weakened, the whole thing fell down and was discredited, as it would not have been had there been an inch more of concrete between the steel and the outside of the posts. I would suggest that no work be put up with less than an inch and a half of concrete outside the steel.

W. K. Hatt, Professor of Applied Mechanics, Purdue University (by letter).—The writer has been greatly interested in Professor Johnson's paper, and desires to add something further concerning the design of reinforced concrete beams. Professor Johnson's simple method will, in the opinion of the writer, yield safe and reasonably economical sections. At the present time it is probable that these beams must be designed on the basis of the strength at the point of first crack; but when a knowledge of constants is extended, and the mechanical analysis is simplified, we may hope to design such beams with factors of safety chosen with reference to a point in flexure of these beams corresponding to the yield point in most materials. This point has been called "Point A" in the Load-Deflection Diagrams presented by the writer in the "Proceed-

ings of the American Society for Testing Materials," Vol. II, 1902. One of these diagrams is here reproduced.

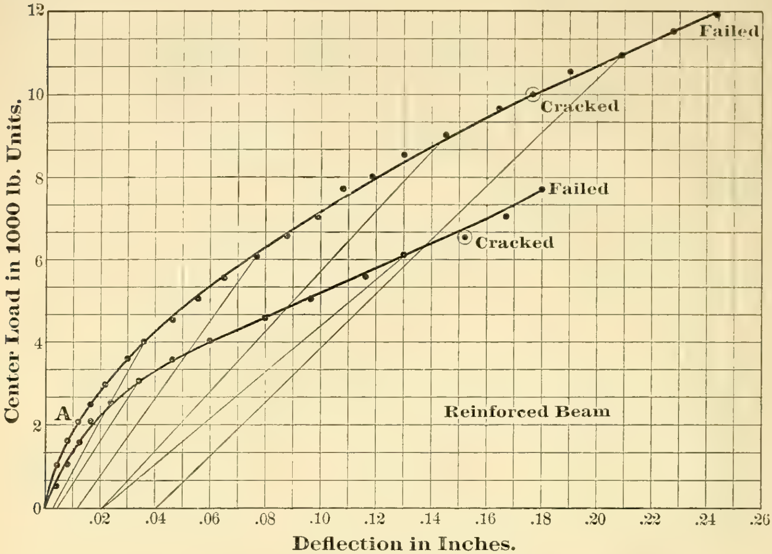


Fig. 1. Load-Deflection Diagram of Reinforced-Concrete Beam.

Professor Johnson has used the value of 7.5 for the ratio of the modulus of elasticity of steel in tension to the modulus of elasticity of concrete in compression. The writer desires to quote certain results recently obtained in experiments performed in the laboratory for testing materials of Purdue University, which justify the use of this value of the constant. Table I gives the modulus of elasticity, and the strength of both broken stone and gravel-concrete at twenty-eight and ninety days. The limestone was the product of the crusher below 1 inch. The gravel was excellent pit gravel, including sand and pebbles. The concrete was medium wet. The values quoted are based upon tests of thirty-seven compression specimens, involving 202 determinations of the modulus in compression, and on tests of twenty-seven tension specimens, involving seventy-nine determinations of the tension modulus. From these results it appears that the ratio of the modulus of elasticity of concrete in compression to that in tension is nearly unity. The ratio of the modulus of elasticity of the steel in tension to the concrete in compression is as follows:

Stone-concrete	28 days.	8.8
" "	90 "	6.6
Average		7.7
Gravel-concrete	28 days.	8.0
" "	90 "	6.2
Average		7.1

To add to Professor Johnson's value of the constant K in the formula $M = Kbh^2$, the writer would quote the following Table II,

TABLE I.—MODULUS OF ELASTICITY OF PORTLAND CEMENT CONCRETE.

Kind of Cement.	Concrete Sand.	Broken Stone.	Gravel.	Age.	Compression Modulus.	Tension Modulus.	Ultimate Strength Comp.	Ten.
				Days.	Lbs. per sq. inch.	Lbs. per sq. inch.	Lbs. per sq. inch.	
1	2	5	...	90	4,610,000	5,460,000	2,513	359
1	2	5	...	28	3,350,000	3,800,000	2,290	237
1	...	...	5	90	4,800,000	4,510,000	2,804	290
1	...	...	5	28	4,130,000	4,320,000	2,405	253

TABLE II.—SHOWING VALUE OF K IN FORMULA $M = Kbh^2$ FOR LOADS AT FIRST VISIBLE CRACK IN TENSION.

Beams.		Amount and Depth of Reinforcement.	Age.	K.
STONE with wrought-iron reinforcement.	C. S. Broken Stone. 1-2-4	none	1 month	90
		none	1 week	60
		1% . . . . 1 inch	1 month	265
		1% . . . . 2 inch	1 month	195
		1% . . . . 2 inch	1 week	160
		2% . . . . 1 inch	1 month	391
		2% . . . . 2 inch	1 month	240
GRAVEL with steel reinforcement	C. Gravel 1-5	½% . . . . 1 inch	3 months	161
		1% . . . . 1 inch	3 months	322
		1% . . . . 1 inch	1 month	283
		2% . . . . 1 inch	3 months	526
		2% . . . . 1 inch	1 month	480

Elastic Limit of Iron = 36,000. Elastic Limit of Steel = 33,300. Materials as in Table I. Units, M (moment) in inch-lbs.; b, h in inches.

which is the result of tests made by him on twenty-three beams, 8 x 8 inches in cross-section, tested on a span of 80 inches. These beams were reinforced with plain bars of circular section placed in the tension flange. No provision was made for a bond other than natural adhesion between the concrete and the reinforcement. None of the beams quoted failed in either horizontal or vertical shear. The first indication of failure was always a crack in the tension side of the beam close to the center. The widening of this crack was due to the fact that the yield point of the steel was reached. The strength of the concrete in compression was not developed. The value of a high elastic limit in the reinforcement is evident.

Plate I.

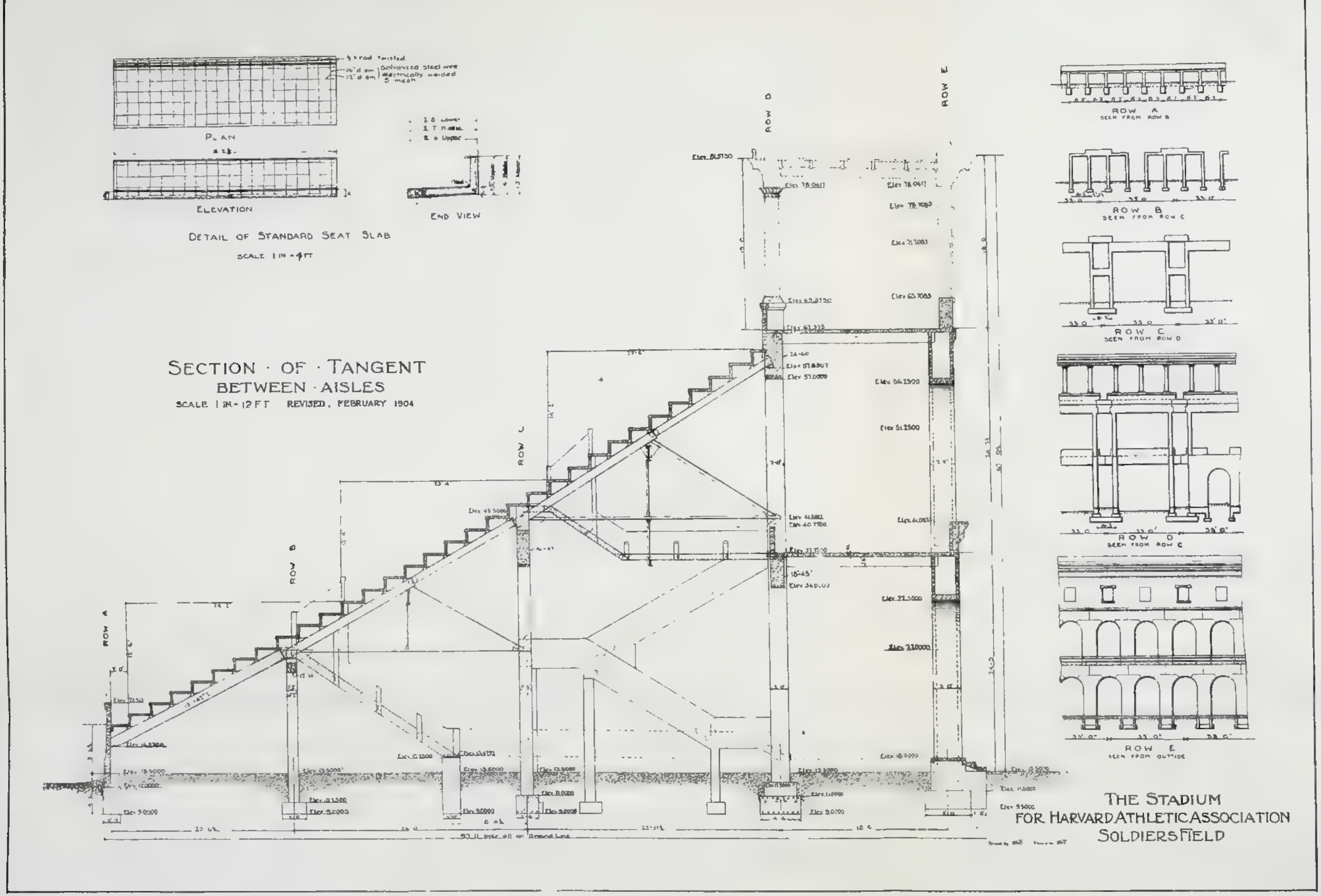
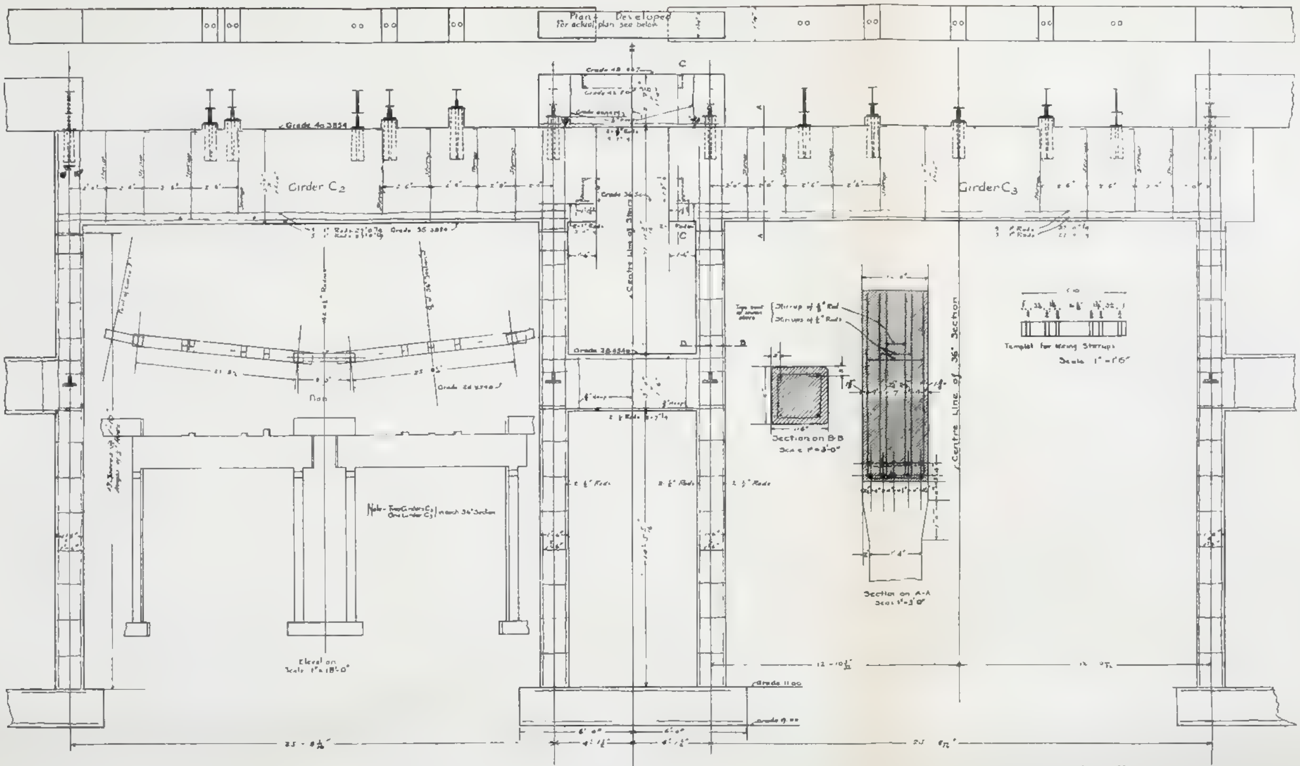

PLAN
ELEVATION
END VIEW
DETAIL OF STANDARD SEAT SLAB
SCALE 1 IN = 4 FT
SECTION · OF · TANGENT
BETWEEN · AISLES
SCALE 1 IN = 12 FT REVISED, FEBRUARY 1904
ROW A
ROW B
ROW C
ROW D
ROW E
ROW A SEEN FROM ROW B
ROW B SEEN FROM ROW C
ROW C SEEN FROM ROW D
ROW D SEEN FROM ROW E
ROW E SEEN FROM OUTSIDE
THE STADIUM
FOR HARVARD ATHLETIC ASSOCIATION
SOLDIERS FIELD

Plate II.



ELEVATION OF COLUMNS - ROW C - CURVE
LOOKING FROM THE FIELD
SCALE 1IN=12FT

THE STADIUM
FOR HARVARD ATHLETIC ASSOCIATION
SOLDIERS FIELD
Sept 8 1903

Plate III.

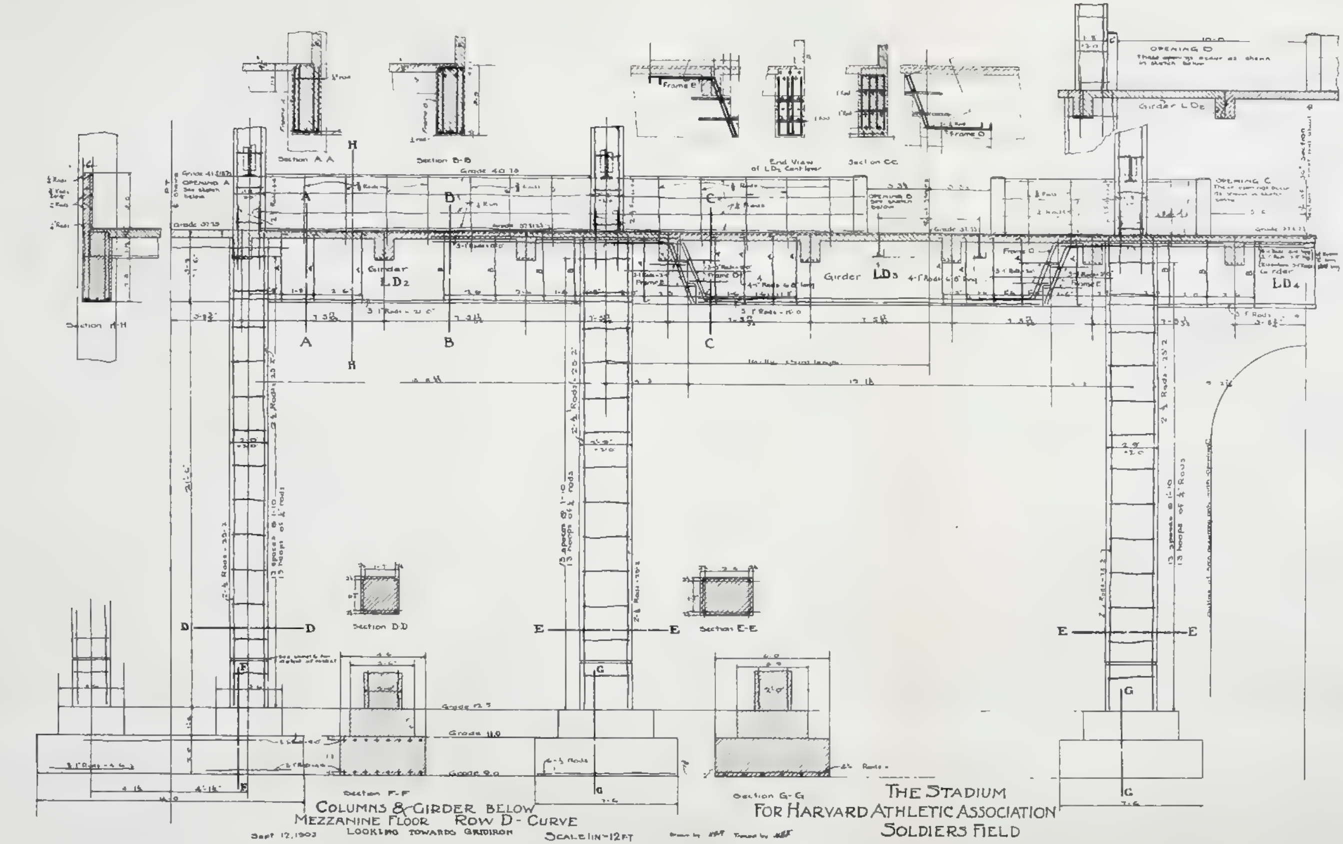

Section A A
Section B-B
End View of LD2 Cantilever
Section C-C
Opening D
Girder LD2
Opening C
Section H-H
Girder LD2
Girder LD3
Girder LD4
Section D-D
Section E-E
Section F-F
Section G-G
Columns & Girder below Mezzanine Floor Row D - Curve
Looking towards Gridiron
Sept 12, 1903
Scale 1 in = 12 ft
The Stadium
For Harvard Athletic Association
Soldiers Field

Plate IV.

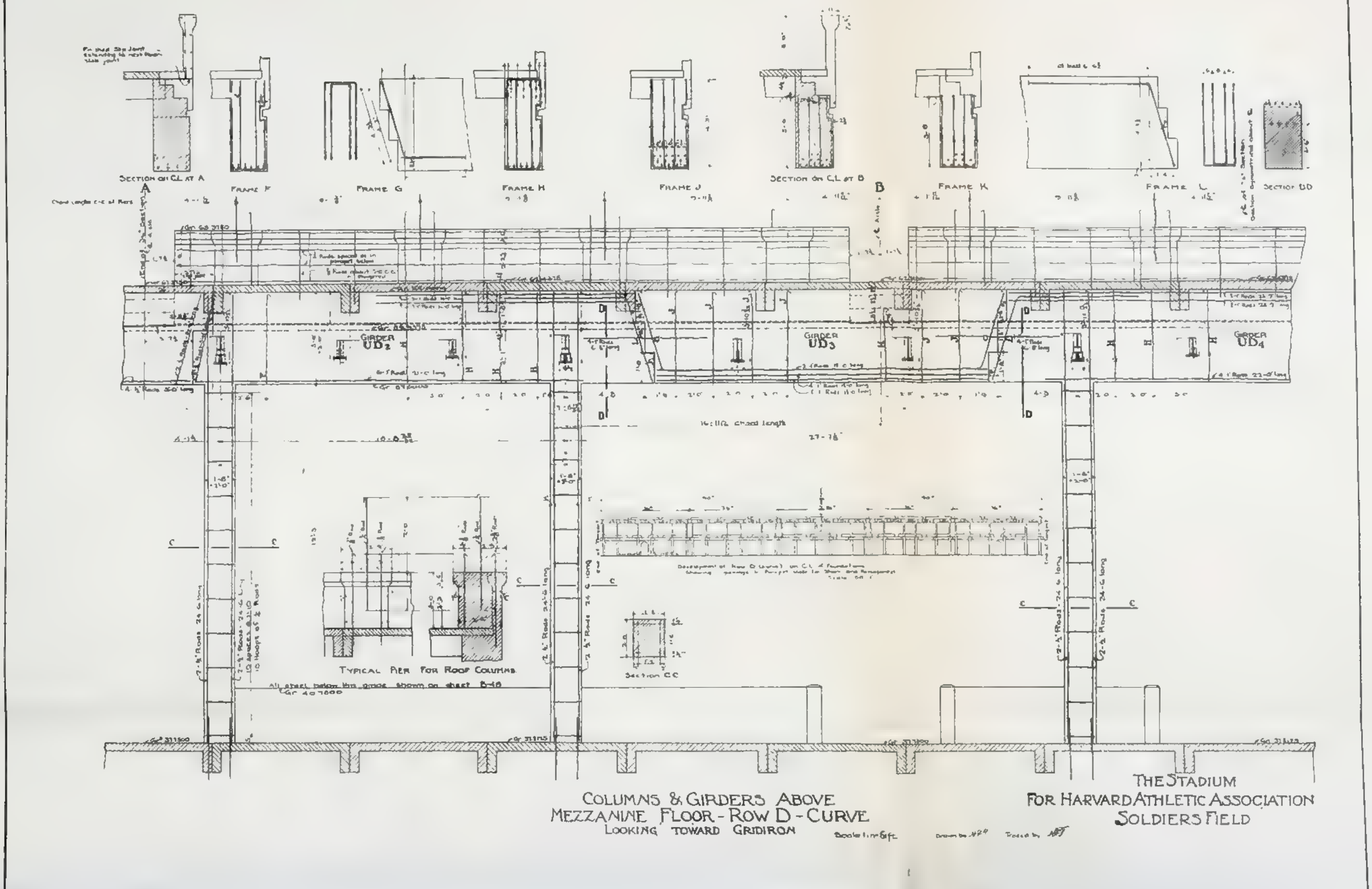
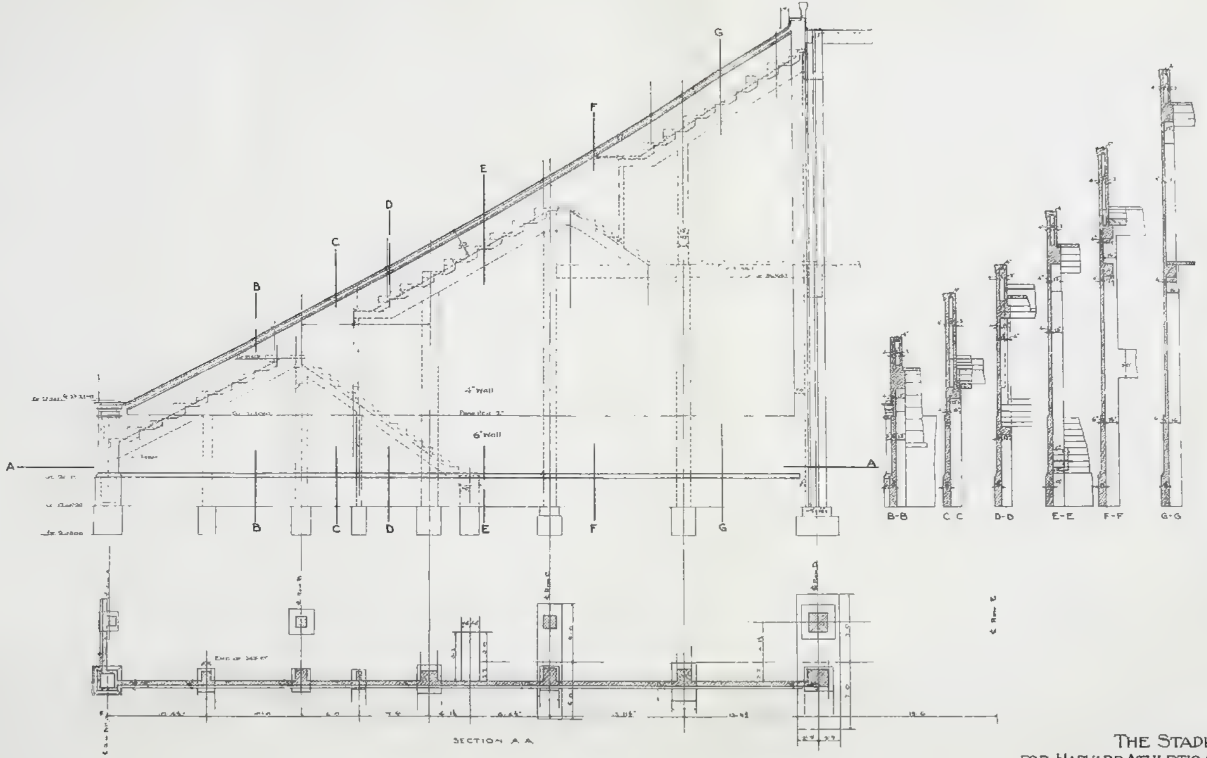
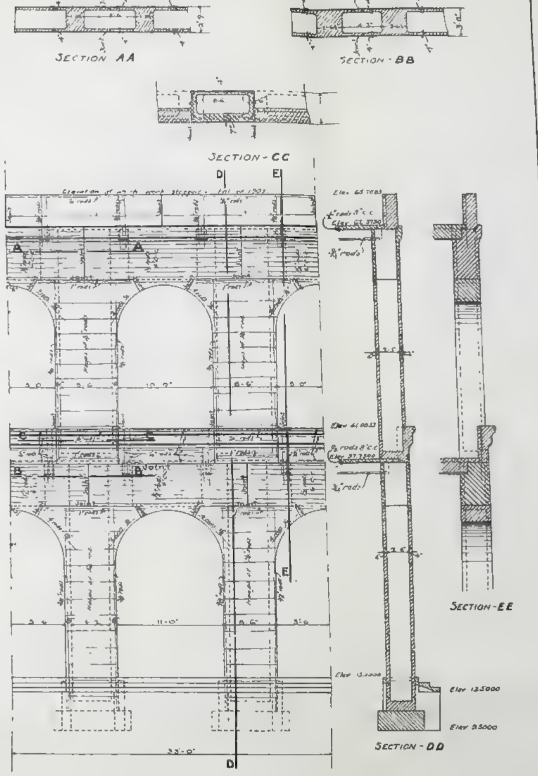

SECTION ON C.L. AT A
FRAME F
FRAME G
FRAME H
FRAME J
SECTION ON C.L. AT B
FRAME K
FRAME L
SECTION DD
GIRDER UD2
GIRDER UD3
GIRDER UD4
TYPICAL PIER FOR ROOF COLUMNS
SECTION CC
COLUMNS & GIRDERS ABOVE
MEZZANINE FLOOR - ROW D - CURVE
LOOKING TOWARD GRIDIRON
THE STADIUM
FOR HARVARD ATHLETIC ASSOCIATION
SOLDIERS FIELD

Plate Va.



ELEVATION OF END WALL
Scale . October 14 1903.

Plate Vb.



THE STADIUM
FOR HARVARD ATHLETIC ASSOCIATION
SOLDIERS FIELD

PORTION OF REAR ELEVATION OF ROW E
SCALE 1 IN = 12 FT.

METHODS FOR DETERMINING THE EQUATIONS OF EXPERIMENTAL CURVES.

By A. S. Langsdorf, Member of the Engineers' Club of St. Louis.

[Read before the Club April 20, 1904.*]

In the course of many investigations of a physical or engineering nature it becomes necessary, or desirable, to reduce the results of the observations to the form of an equation; or, in other words, to deduce a law sufficiently general to cover the full range of observed data. Methods for the accomplishment of this end are undoubtedly known and used by many engineers, but, singularly enough, little concerning this important subject has appeared in technical publications. The discussion herewith presented is therefore brought forward in the hope that it may be of service to investigators desirous of pushing their work to a definite conclusion.

In many cases the law governing the particular conditions under observation may be known at the start, and, therefore, also the general form of its mathematical expression; the problem then reduces to that of determining the numerical values of the constants of the general equation. But it may, and does, happen that an *a priori* determination of the equation is impossible, and it then becomes necessary to devise an empirical equation to represent the facts. This is essentially an inductive process, the other class of problems mentioned above being only a special case of it. Fortunately, the solution of the general case is much facilitated by the fact that the great majority of physical laws are relatively simple, in consequence of which their mathematical expressions do not involve complicated functions of the variables. In fact, the graphical representations of the equations are almost wholly limited to five groups: (1) The straight line; (2) parabolic curves; (3) hyperbolic curves; (4) logarithmic curves; (5) periodic curves. Of these, the first four only will be considered here.†

In treating any particular case the first step consists of plotting the observed data and classifying the curve geometrically. Some uncertainty as to choice may exist here, for with an arbitrary scale of drawing, curves of the second, third and fourth groups may appear indistinguishable; but judicious reasoning as to the limiting

* Manuscript received April 29, 1904.—Secretary, Ass'n of Eng. Socs.

† For a treatment of periodic curves, see a paper by the author on "A Graphical Method for Analyzing Distorted Alternating Current Waves," *Physical Review*, vol. xii, p. 184.

conditions of the experiment will often furnish a clue not otherwise available—such, for instance, as the presence or absence of asymptotes, the slope of the curve at particular points and other similar considerations. Under the most unfavorable conditions a trial of several typical forms will indicate which is likely to prove the best. When the curve has been tentatively classified, the characteristic equation may be assigned to it, and it then remains to evaluate the constants entering therein.

In order to examine the methods of analysis in detail, each group will be treated separately, and illustrated by more or less specific examples.

THE STRAIGHT LINE.

Suppose that a series of observations of two related variables gives the data which are plotted in Fig 1. The average line through the points is evidently straight, its position being determined by stretching a thread across the paper until the points above and below it balance. The general equation of the line is

$$y = ax + b \qquad (1)$$

Select two points, such as p and q, on the line, and as far apart as possible; they should preferably be taken where the line crosses the intersection of two of the co-ordinate rulings, for greater accuracy in reading. The co-ordinates of p and q must satisfy (1), so that on substituting these values from the figure we have the two simultaneous equations

$$26.5 = 3.5\,a + b$$
$$3.0 = 81.0\,a + b$$

from which $a = -0.303$ and $b = +27.56$, or

$$y = 27.56 - 0.303\,x$$

It is to be observed that this method gives to the final values of a and b the accuracy of the method of least squares. For a and b depend upon the slope and position of the line, which, in turn, depends upon *all* the points plotted; from which it follows that the result is the same as if each observation were weighted. Thus, if through some error of observation, one of the plotted points falls considerably off the average line, the position of the latter will not be appreciably affected thereby, and hence the error will not appear in a and b, as would be the case if the constants were found by direct substitution of observed values in (1).

The case of the straight line has been treated thus fully because the methods for the other cases are such that the final part of

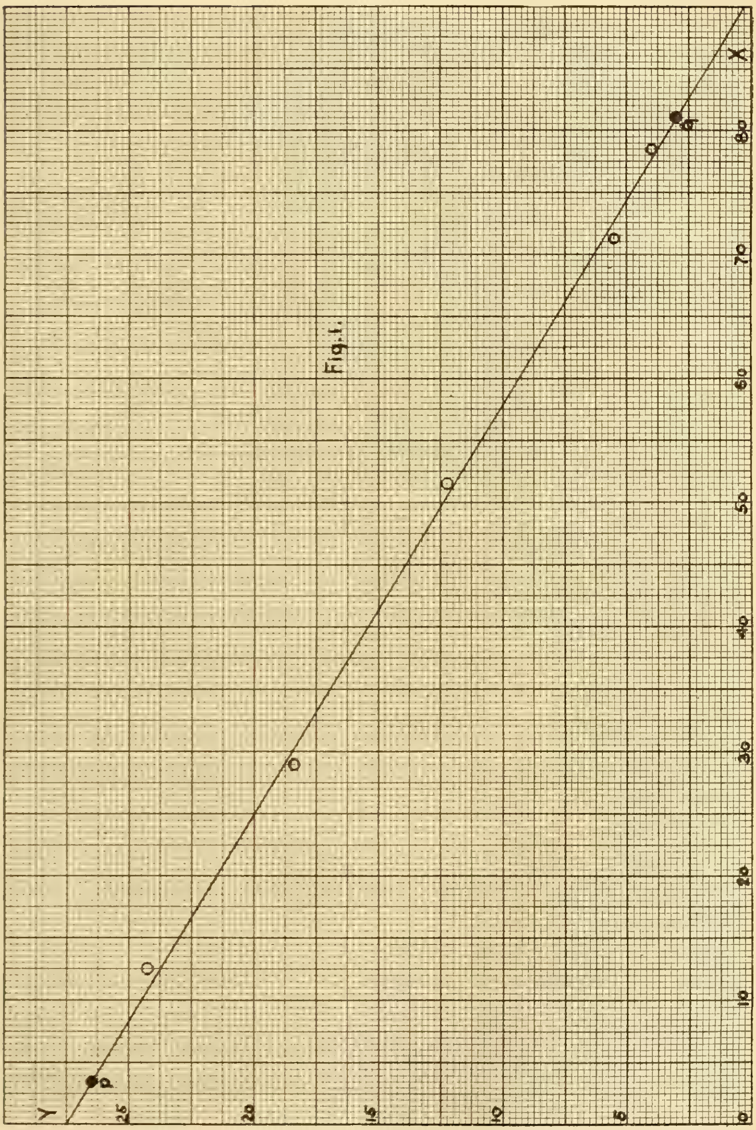


Fig. I.

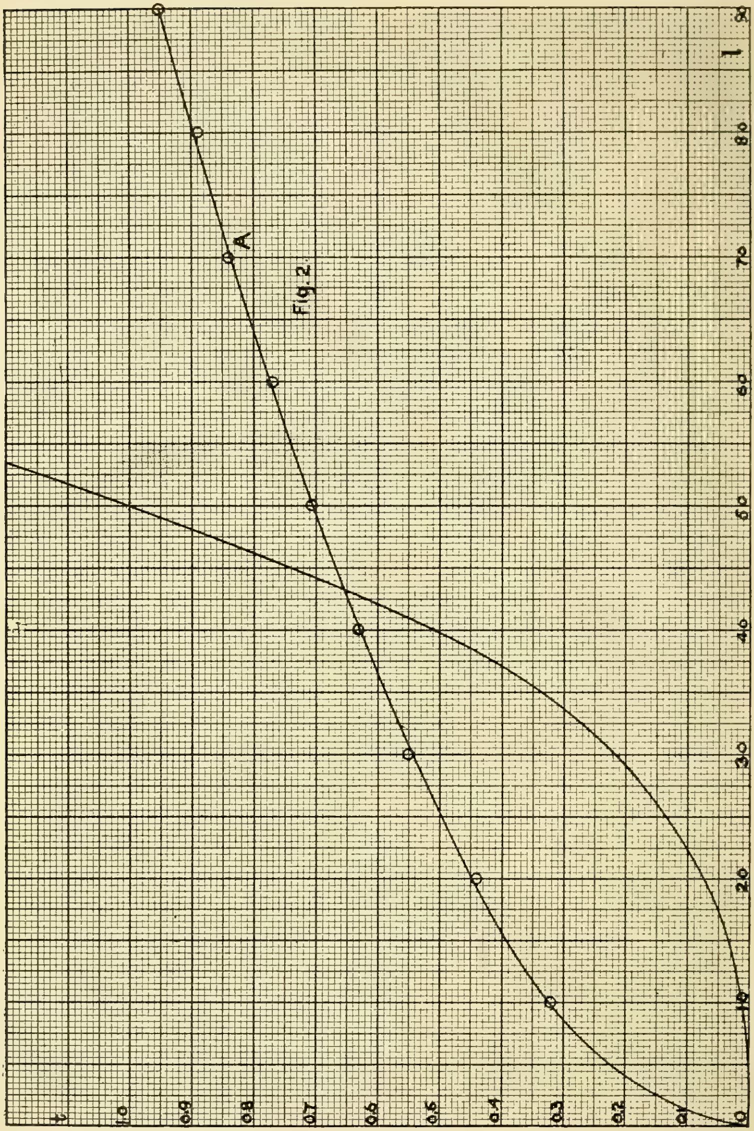


Fig. 2.

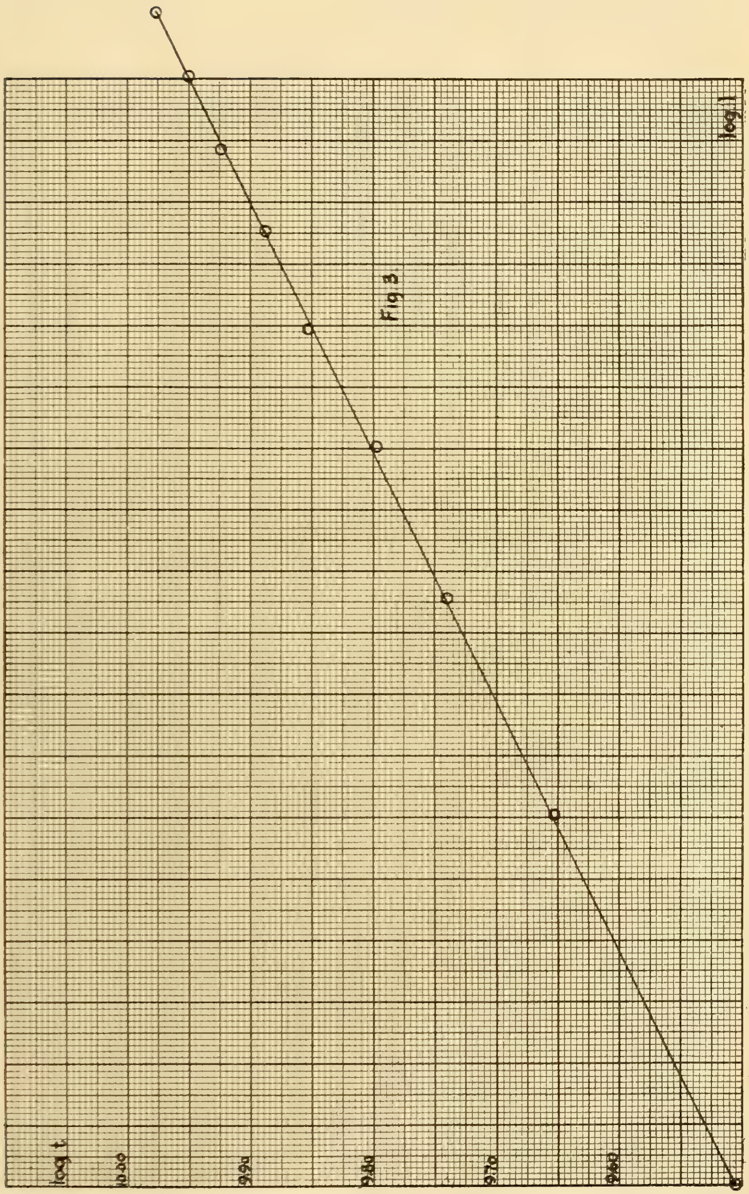


Fig. 3

each process involves the determination of the constants from a straight line. A due appreciation of the accuracy thus obtained is, therefore, essential.

PARABOLIC CURVES.

The general equation of curves of this class (as encountered in practical work) is

$$y - a = k\ (x - b)^n \qquad (2)$$

the vertex of the curve being at the point (b, a). In Fig. 2 are shown two curves of this class, but in both cases the vertex is at the origin.

The curve will be convex or concave to the axis of X according to whether n is greater or less than unity, respectively.

When the vertex is at the origin, equation (2) becomes

$$y = kx^n \qquad (3)$$

Curve A, for example, has been plotted from the results of an experiment with a simple pendulum, the ordinates being the times of oscillations in seconds, and the abscissas the corresponding lengths in centimeters. Assuming (3) as the form of the equation of A, we may write

$$\log y = \log k + n \log x \qquad (4)$$

If the assumption is correct, then on plotting log y and log x, a straight line should result (as in Fig. 3), since (4) is of the first degree in these variables. This being found to be the case, we may proceed to evaluate log k and n as described under The Straight Line, thus finding the values

$$n = 0.495 \text{ (or nearly 0.5)}$$
$$\log k = 9.011 - 10,\ k = 0.102$$

Therefore,

$$t = 0.102\ \sqrt{l}$$

The agreement with theory is very close, since the actual formula is

$$t = \frac{\pi}{\sqrt{g}}\sqrt{l} = 0.1006\sqrt{l}$$

The value of n for curves of this class may be found in another way by virtue of a property possessed by exponential curves. Differentiating (3), we have

$$\frac{dy}{dx} = knx^{n-1} \qquad (5)$$

dividing (3) by (5), and transposing,

$$n = \frac{x}{y}\frac{dy}{dx}$$

but, according to Fig. 4, $\frac{dy}{dx} = \frac{PN}{TN}$, $x = ON$, $y = PN$, therefore,

$$n = \frac{ON}{TN}$$

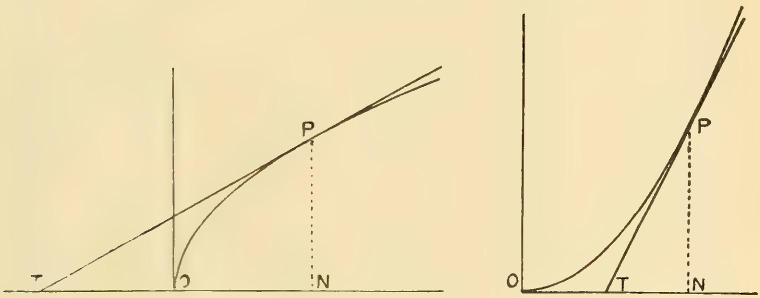


FIG. 4.

That is, n is the ratio of the abscissa of any point of tangency to the corresponding subtangent, provided the vertex is on the axis of X. If, therefore, a number of tangents to the curve are drawn, and this ratio found for each case, an average value of n may be obtained. This method is disadvantageous in that it does not show clearly the truth or falsity of the original assumption concerning the parabolic nature of the curve; this is particularly the case when successive values of n show a slight tendency to deviate regularly from a mean value.

The general case, in which the vertex of the curve is displaced from the origin, is rather more difficult to handle than that discussed above. It will be noted that the characteristic equation (2) contains four constants, at least two of which must be eliminated before the remaining two can be found. Differentiating (2), we have

$$\frac{dy}{dx} = kn\,(x - b)^{n-1} \qquad (6)$$

which disposes of one constant. If now b can be evaluated, equation (6) will take the form

$$y_1 = knx_1^{n-1}$$

where

$$y_1 = \frac{dy}{dx}$$
$$x_1 = x - b$$

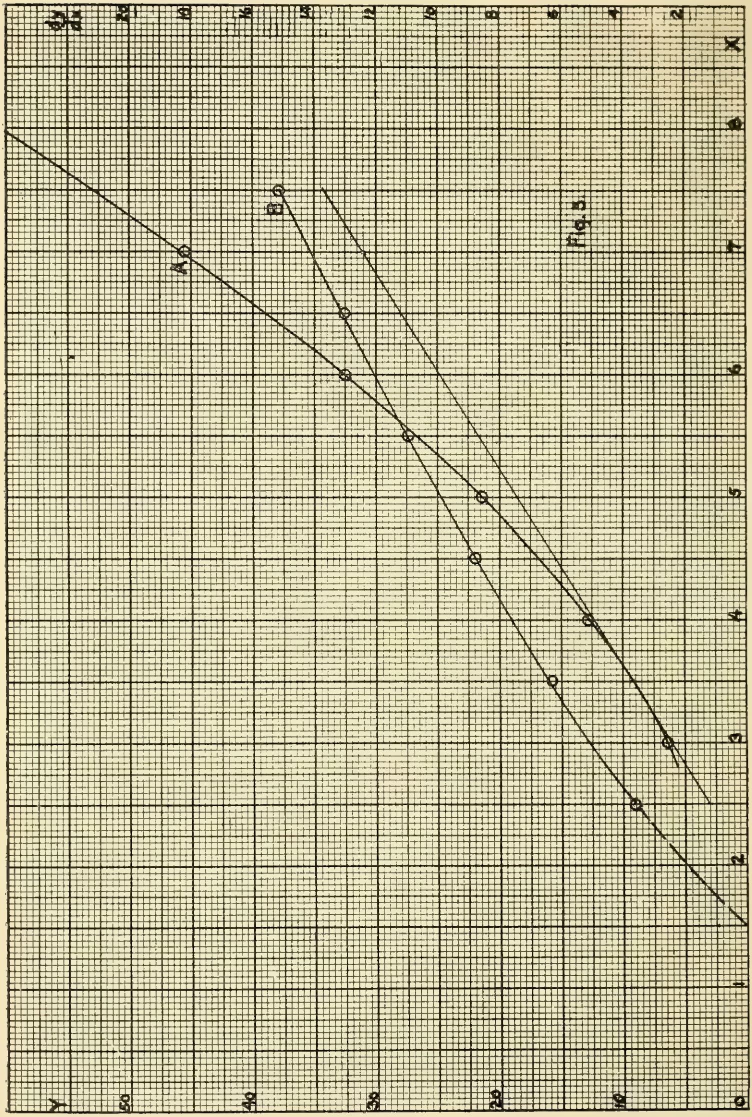


Fig. 5
A
B
X
Y
dy/dx
0 1 2 3 4 5 6 7 8
10 20 30 40 50
2 4 6 8 10 12 14 16 18 20

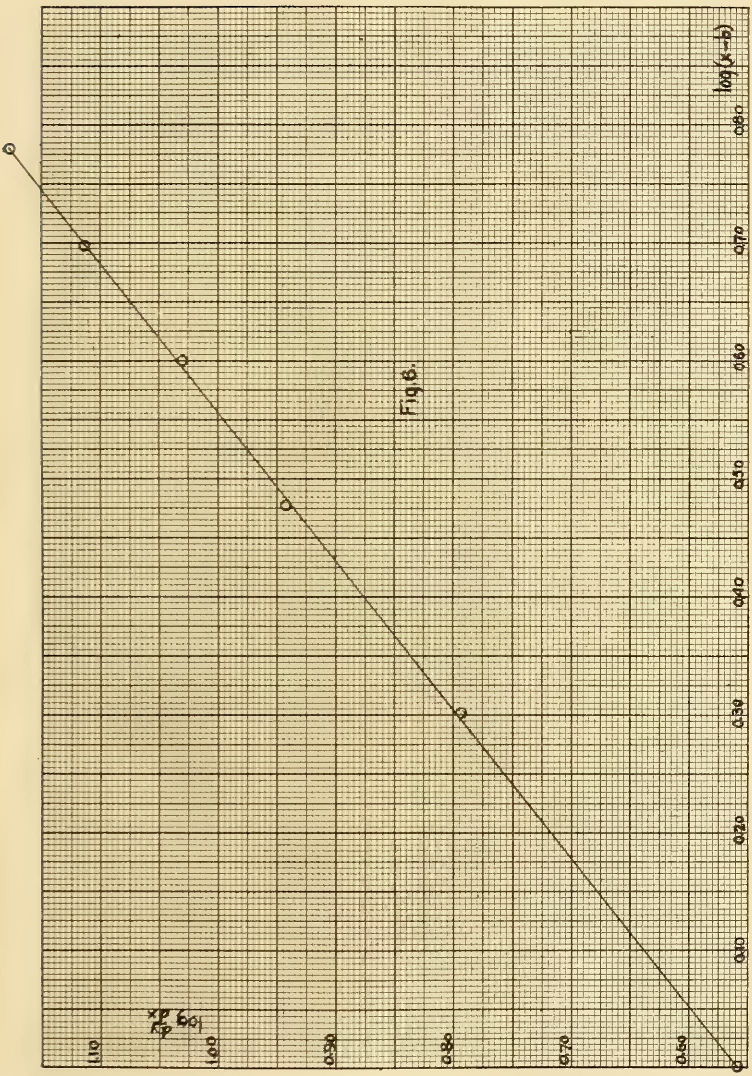


Fig. 6.

this is similar in form to equation (3), and the method of solution given for that case will then apply.

For example, suppose that curve A of Fig. 5 is to be analyzed, the data from which it is plotted being included in the subjoined table. Construct a number of tangents to the curve, as indicated, and find the numerical value of $\frac{dy}{dx}$ for each point of tangency. Now construct curve B (Fig. 5), whose ordinates are these values of $\frac{dy}{dx}$ and whose abscissas are the points of tangency. Produce curve B until it intersects the axis of X. The abscissa of this point will then be the value of *b*. Naturally, there will be some uncertainty as to this value, but it may be found with sufficient exactness in two or three trials.

Referring to Fig. 5, *b* is found to be 1.5, so that in the table we may form the column (x — b). Since

$$\frac{dy}{dx} = kn\,(x - b)^{n-1}$$

it follows that

$$\log \frac{dy}{dx} = \log (kn) + (n - 1) \log (x - b)$$

which is linear in $\log \frac{dy}{dx}$ and $\log (x - b)$. Plotting these quantities as in Fig. 6, we obtain a straight line, from which can be found

$$\log (kn) = 0.557$$
$$n - 1 = 0.796$$

therefore,

$$n = 1.8 \text{ (approximately)}$$
$$k = 2.0$$

Having determined *b, k,* and *n,* it is a simple matter to fix the value of *a*; in this case, a = 2.3; so that, finally,

$$y - 2.3 = 2.0\,(x - 1.5)^{1.8}$$

Data for Figs. 5 and 6.

x	y	x	$\frac{dy}{dx}$	x — b	$\log \frac{dy}{dx}$	log (x — b)
2.0	2.87	2.5	3.60	1.0	0.556	0.000
3.0	6.45	3.5	6.23	2.0	0.794	0.301
4.0	12.71	4.5	8.78	3.0	0.943	0.477
5.0	21.37	5.5	10.89	4.0	1.037	0.602
6.0	32.27	6.5	13.05	5.0	1.116	0.699
7.0	45.32	7.5	15.10	6.0	1.179	0.778

If an appreciable error is made in selecting the value of *b,* the line of Fig. 6 will be curved instead of straight; if *b* is taken too

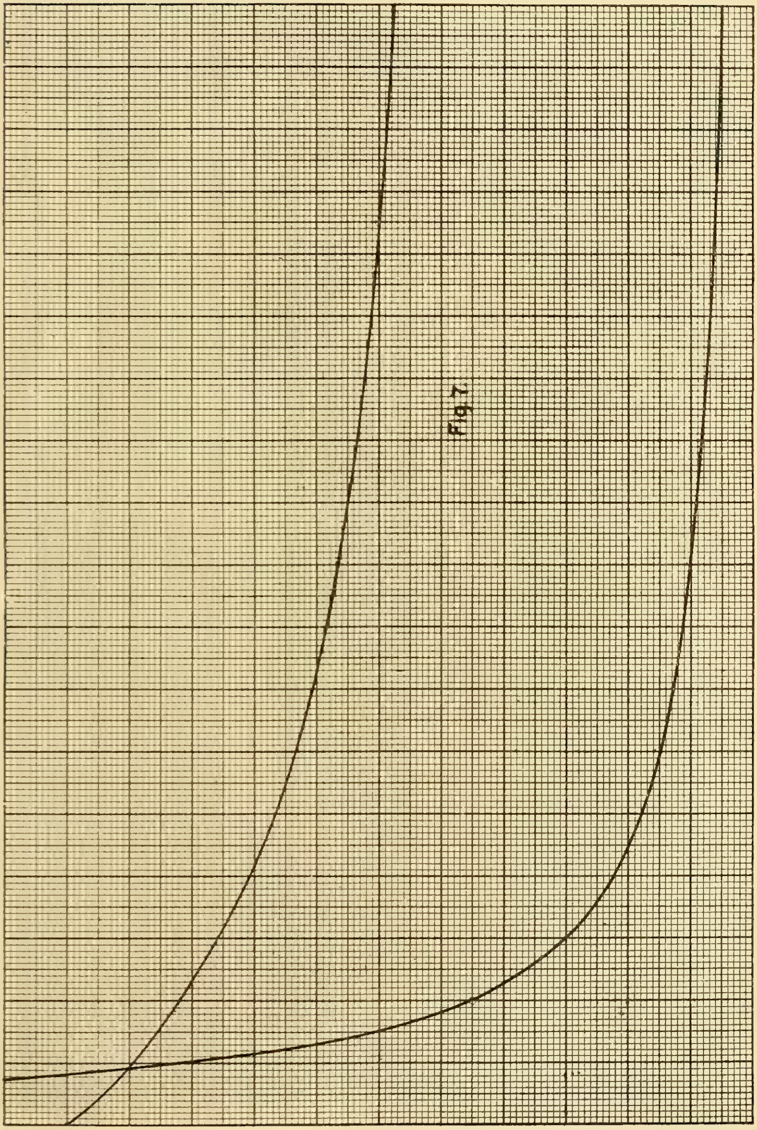


Fig. 7.

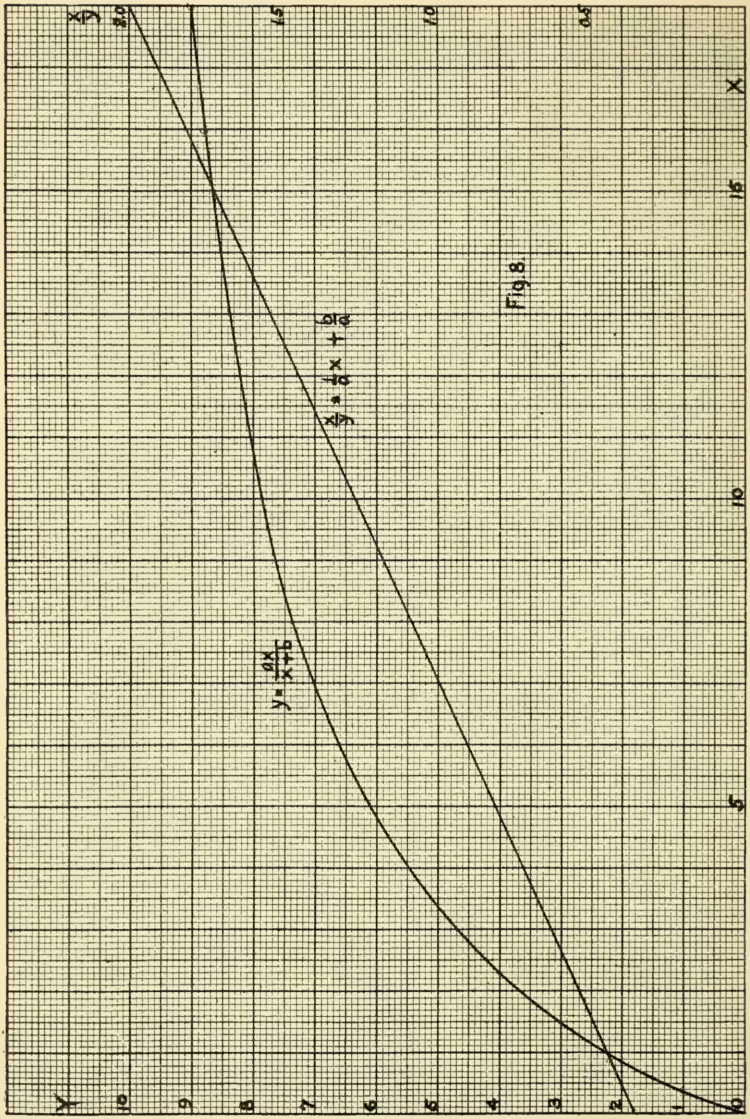


Fig. 8.

large the curvature will be in one direction, and if too small, in the other. Hence, if two such curves are obtained in the course of the work, the true value of b will be between those from which the trial curves resulted, and can be closely approximated by visual interpolation.

The general case here discussed will, of course, fully cover those special cases in which either a or b is absent. If a is zero, the curve will be tangent to the X axis at a distance b from the origin. If b is zero, the origin will be on the axis of Y at a distance a above the origin. It is hardly necessary to add that a and b, in all these equations, may be either positive or negative.

HYPERBOLIC CURVES.

Curves of this class (Fig. 7) may be treated in a manner very similar to that used for parabolic curves. In fact, equation (2) becomes that of a hyperbolic curve if n is negative; in that case the equation may be written

$$(y - a)\ (x - b)^n = k \qquad (7)$$

where n is positive.

Differentiating (7), we have

$$-\frac{dy}{dx} = kn\ (x - b)^{-(n+1)} \qquad (8)$$

or

$$-\frac{1}{\frac{dy}{dx}} = \frac{(x - b)^{n+1}}{kn}$$

If tangents to the curve are drawn at a number of points and corresponding values of x and $\frac{1}{\frac{dy}{dx}}$ are plotted, the curve so determined will cross the axis of X where $x = b$. It is then possible to proceed as in the case of parabolic curves, noting that equation (8) may be written

$$\log\left(-\frac{dy}{dx}\right) = \log\ (kn) - (n + 1)\log\ (x - b) \qquad (9)$$

There is no anachronism in the expression $\log\left(-\frac{dy}{dx}\right)$, since for all positive values of $(x - b)$, $\frac{dy}{dx}$ will be negative for that branch of the curve lying in the first quadrant.

Hyperbolas are sometimes encountered which have such a position with respect to the axes that they may be readily mistaken for parabolas. Fig. 8 illustrates this class, the general equation of which is

$$y = \frac{ax}{x + b} \qquad (10)$$

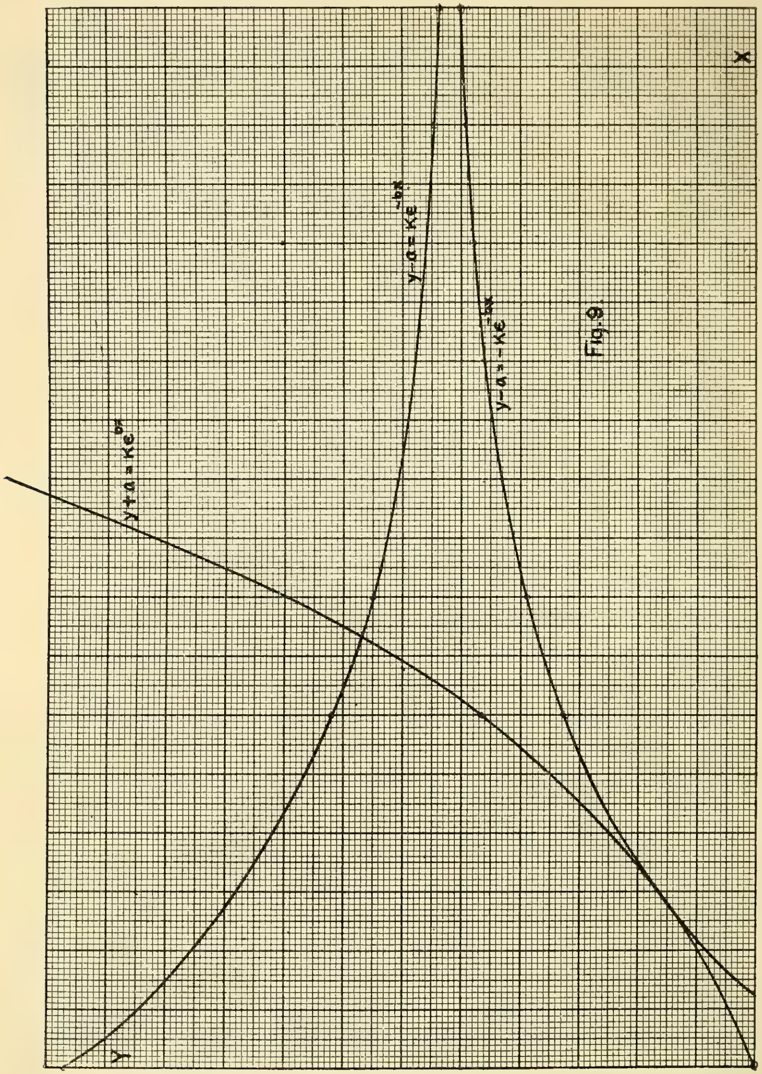


Fig. 9

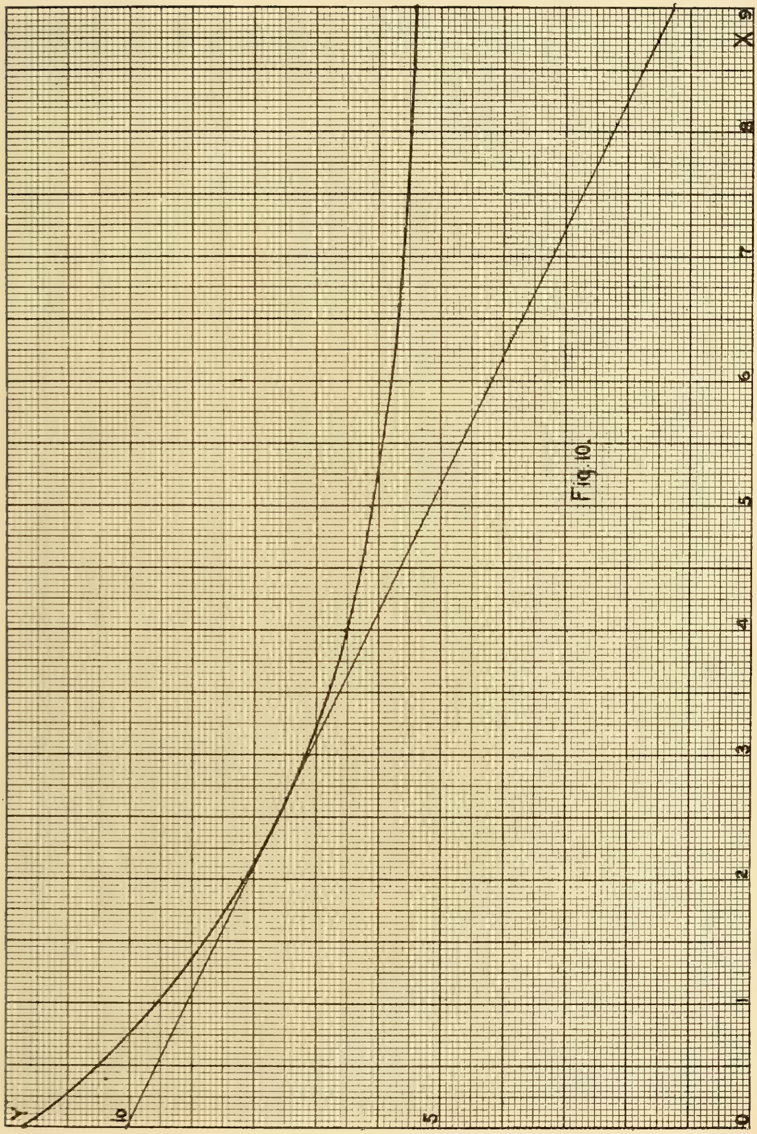


Fig. 10.
X
Y
0
1
2
3
4
5
6
7
8
9
5
10

If this curve is mistaken for a parabolic one, and the method of analysis involving equations (3) and (4) is employed, the graph of (4) will not be a straight line, thus showing the falsity of the assumption. Close inspection of the actual curve will usually determine which of the two equations (3) or (10) is the better for a first trial, since the graph of the former is tangent to one of the axes, while that of the latter is not.

Equation (10) may be written

$$\frac{x}{y} = \frac{1}{a} x + \frac{b}{a}$$

which is linear in $\frac{x}{y}$ and x; if, therefore, (10) is the true equation of the curve, a straight line should result on plotting $\frac{x}{y}$ and x; and from this line $\frac{1}{a}$ and $\frac{b}{a}$, and thence a and b, may be found. It may be remarked in passing that $x = -b$ and $y = a$ are asymptotes of the curve.

The B-H curve of magnetization and the saturation characteristics of a generator may be conveniently represented by (10), which is identical in form with Frölich's equation.

LOGARITHMIC CURVES.

The general equation of this type is

$$y - a = k\varepsilon^{bx} \qquad (11)$$

where ε is the base of the Naperian system of logarithms, and a, b, and k are constants which may have any values. The variables x and y may be interchanged in (11), in which case the resulting curve and that represented by (11) will be symmetrical with respect to the line $y = x$. In Fig. 9 are shown several typical curves obtained by giving various positive and negative values to the constants.

Differentiating (11), we have

$$\frac{dy}{dx} = kb\,\varepsilon^{bx} \qquad (12)$$

from which

$$\log_\varepsilon \left(\frac{dy}{dx}\right) = \log_\varepsilon (kb) + bx \qquad (13)$$

Equation (13) is linear in $\log_\varepsilon \left(\frac{dy}{dx}\right)$ and x, so that if a straight line results from plotting these functions it follows that (11) correctly represents the original curve. In addition, the values of b and k follow at once from this straight line according to methods already illustrated. Knowing b and k it is a simple matter to determine a from the original data and curve.

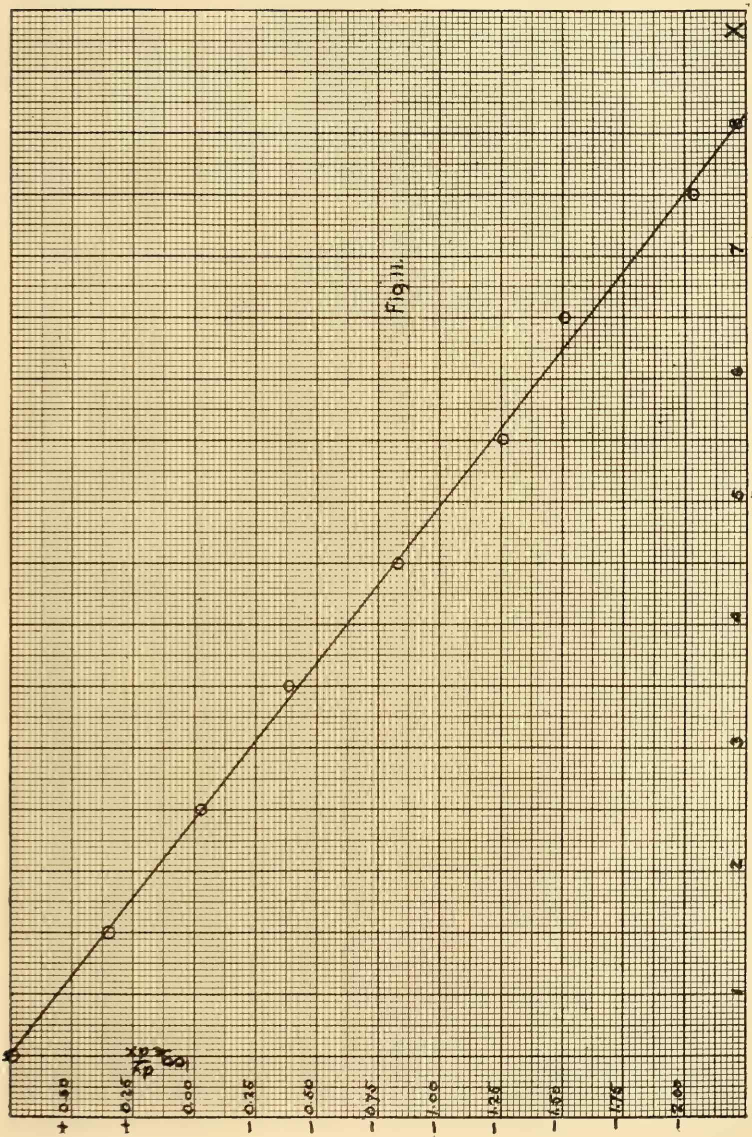


Fig. 11.

For example, suppose that the curve of Fig. 10 is to be analyzed, and that the original data is contained in the following table. Construct a number of tangents, as indicated, and find the value of $\frac{dy}{dx}$ for each. In the present case, all these values are negative, which indicates at once that b must be negative. But it follows from (12) and (13) that if we take the absolute values of $\frac{dy}{dx}$ and treat them as positive, b will necessarily come out as a negative quantity.

Plotting $\log_\varepsilon\left(-\frac{dy}{dx}\right)$ and x, as in Fig. 11, a straight line is obtained, from which is calculated

$$\begin{aligned} b &= -0.394 \\ \log_\varepsilon bk &= 0.951 \\ bk &= 2.59 \\ k &= 6.57 \end{aligned}$$

It should be noted that in dividing bk by b their absolute values must be used.

We thus obtain

$$y - a = 6.57\varepsilon^{-0.394x}$$

and, upon inserting a number of corresponding values of x and y from the original curve, the average value of a is found to be 5.2; therefore,

$$y - 5.2 = 6.57\varepsilon^{-0.4x} \text{ (nearly)}$$

is the final expression.

DATA FOR FIGS. 10 AND 11.

x	y	x	$-\frac{dy}{dx}$	$\log_\varepsilon\left(-\frac{dy}{dx}\right)$
0	11.70	0.5	2.100	+0.742
1	9.56	1.5	1.420	+0.351
2	8.12	2.5	0.975	—0.025
3	7.16	3.5	0.663	—0.411
4	6.51	4.5	0.436	—0.830
5	6.08	5.5	0.286	—1.252
6	5.79	6.5	0.221	—1.505
7	5.60	7.5	0.130	—2.040
8	5.47			
9	5.38			

SUMMARY.

In the methods described in the foregoing sections, the form of the tentative equation is modified by any legitimate process in such a manner that the variables in the original equation become

collected into two groups, or terms, all other terms involving constants only. On calculating the values of these group terms from the original data, and plotting them as new variables, a straight line should result if the assumed form of equation is correct. The chief advantage of this method lies in the fact that the values of the constants thus determined have far greater accuracy than could be otherwise obtained. It will also be observed that for all the curves treated as in the above sections, the principal functions to be handled are, besides x and y themselves, $\frac{dy}{dx}$, $\log \frac{dy}{dx}$ and $\log x$ (or $\log (x - b)$). When these functions have been calculated, they may be used quickly for trying the various possible combinations.

The methods thus described apply, of course, only to the limited number of cases explained; but they may be readily extended in a manner that will be at once evident to anyone familiar with the equations of other families of curves.

THE UTILIZATION OF NIAGARA POWER.

By H. W. Buck, Electrical Engineer, Niagara Falls Power Company.

[Read before the Engineers' Society of Western New York, April 5, 1904.*]

The utilization of the power of Niagara Falls has for years been the dream of engineers and of all those interested in the industrial development of this section of the country. In the past, many schemes for the purpose have been suggested by inventors and others, but never, until the advent of the modern era in electrical engineering, has the proposition, on a large scale, been able to stand upon a basis attractive to the capitalist. It may therefore almost be claimed that the problem of utilizing the power of Niagara has been solved technically by the profession of electrical engineering.

The difficulty in the past has not been to apply the water to the turning of a water wheel, for many of the schemes suggested would have accomplished this successfully, but what to do with the power when developed at the water-wheel shaft was the problem before the engineer. Obviously, here the question of transmission arose as of prime importance.

Among the numerous early plans will be found extensive systems of pneumatic tubes operated by turbine-driven air compressors, the pipes leading to factories located in the vicinity of a power house. Each factory was to have its own air motor thus operated. It may be of interest to note that one of these plans contemplated the transmission of power to Buffalo by this means.

Another plan consisted in lines of countershafting bracketed on columns extending radially from a central power station, this long shafting to be driven by the water wheels through a system of gearing. Factories were to be located along these lines of shafting and were to receive their power supply by clutches connected to these shafts.

Still another plan involved the construction of a network of surface canals fed from a common intake from the Niagara River. Factories were to locate along these canals and take water from them for the operation of individual turbines; the water to be discharged into branch tunnels connected to a main trunk tunnel leading to the lower river.

These plans now look grotesque, but at that time, 20 years ago or so, they were seriously considered by good engineers. They

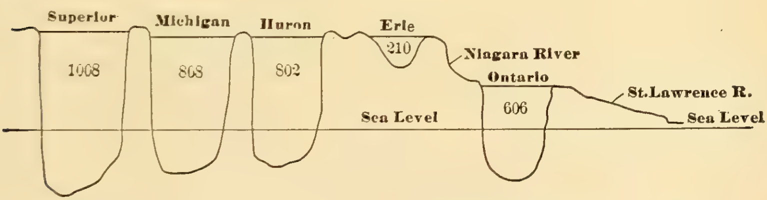
* Manuscript received May 6, 1904.—Secretary, Ass'n of Eng. Socs.

were discarded largely for financial reasons, the plans showing low efficiency and high cost of construction and maintenance.

We are all familiar with the final solution of the problem, and the power house of the Niagara Falls Power Co. need not be described in detail. The electrical solution seems almost ideal as a means of distributing the power. A dynamo has no links, gears or valves to wear out. It revolves day in and day out, with almost no attention, and its efficiency is so high that 98 per cent. of the energy of the turbine shaft is delivered at the terminals of the dynamo. From the electric generator the current is carried over wires and cables which afford almost the limit of simplicity as a means of transmitting power to the user.

Many who come for the first time to the Niagara power house are surprised to find the plant located so far from the Falls. They have always associated the use of Niagara's power with the Falls themselves, and it is difficult for them to understand that the power is derived from the difference in level between the upper and the lower river, of which the Falls are merely a result.

The person who originated the conundrum about not being able to "dam" Niagara knew very little about hydraulic conditions there. The Falls are the direct result of an enormous dam which extends from Buffalo to the brink of the Falls for its thickness, and for its length it has the length of the entire Niagara escarpment itself, the spillway being the Niagara River. If it were not for this dam the waters of Lake Erie would be discharged abruptly into Lake Ontario.



PROFILE OF THE GREAT LAKES, SHOWING THEIR DEPTHS IN FEET.

The ultimate hydraulic conditions at Niagara, therefore, are not so different from those of other water-power plants, except in the matter of size and from the fact that the dam has been built by nature and not by man.

From the electrical distribution of Niagara power has resulted a radical and essential advantage which was not fully recognized at the time of its first adoption. As its uses have developed, it has been found that not only was *power* wanted for industrial purposes, but primarily *electric* power. This is especially true in

the case of the electro-chemical and electric lighting applications. If pneumatic, hydraulic or mechanical shaft power had been supplied for use it would have been necessary for all the electro-chemical plants to convert this power into electric current before they could use it, with all the loss in power which would result from this conversion. So also with the electric lighting and electric railway applications, where power is wanted in the form of electric current.

The first power house of the Niagara Falls Power Co. has a capacity of 50,000 horse power, made up of 10 generating units of 5000 horse power each. The second plant of this same company, which is located on the opposite side of the inlet canal, has just been completed, and its capacity is 55,000 horse power from 11 generators of 5000 horse power each.

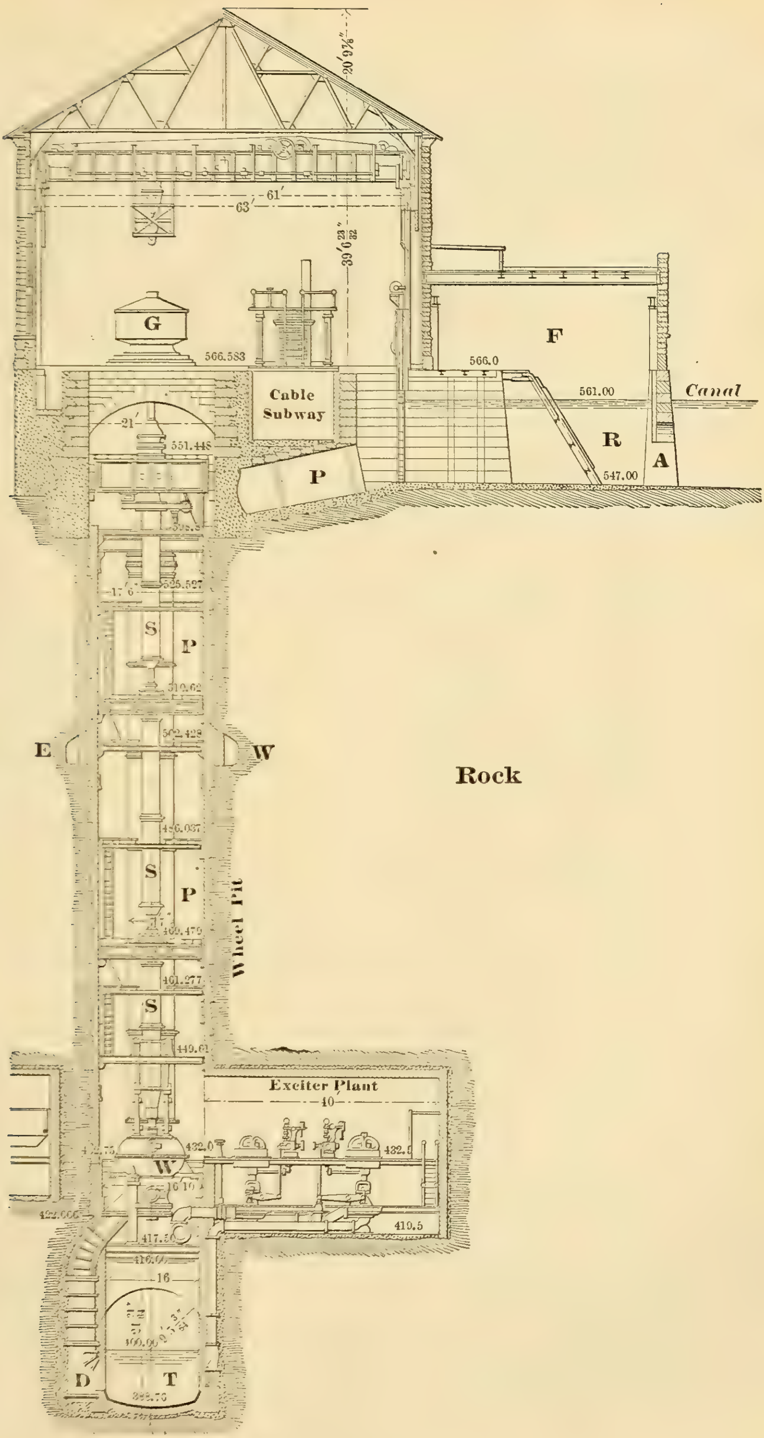
The general features of this plant are the same as those of the older power house, the difference being in a few details. The turbines are operated with draft tubes which increase the effective head of water and consequently the power for a given amount of water. The water is drawn from the old canal, led through penstocks to the turbines and discharged through them into a branch tunnel. This connects with the main tunnel at a point near the end of wheel pit No. 1.

The cut opposite shows power house No. 2 in section, and illustrates one unit and the general method adopted by the Niagara Falls Power Co. of using the hydraulic energy at Niagara. From the canal which connects with the upper river the water flows through submerged arches A as shown and into the inclosed forebay F, thence through the racks R into the penstocks P and down the wheelpit to the turbines which are inclosed in the wheel case W. From the wheel case the water passes through the buckets of the turbine and down through the draught tubes D into the tailrace T. This connects with the discharge tunnel which carries the water off under the city to the lower river.

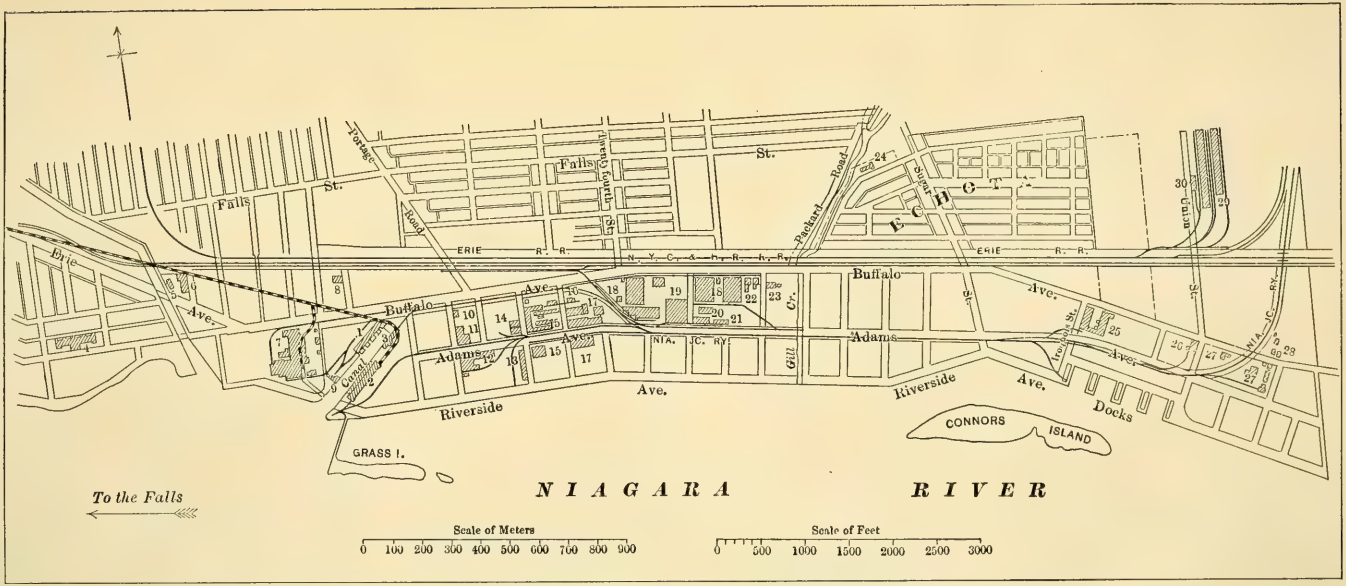
The turbine is direct connected to the electric generator G by means of the vertical hollow shaft S. The speed is 250 revolutions per minute.

Electrically, the arrangements of power house No. 2 differ materially from those of the old plant. There are 2 types of dynamos. The first 6 are very similar to the 10 machines in plant No. 1, but the last 5 are entirely different in construction; in them the field revolves inside of the stationary outside armature.

In the new plant the generators are all wound for the same voltage, phase and frequency as in the old plant machines, so as to permit of interchangeable operation on the system. The



Section of Power House No. 2.



THE NIAGARA FALLS POWER CO. GENERAL MAP SHOWING LOCAL DISTRIBUTION OF ELECTRIC POWER.

1. Power House No. 1.
2. Power House No. 2.
3. Main Transformer Station.
4. The Natural Food Co.
5. Francis Hook and Eye and Fastener Co.
6. Niagara Surface Coating Co.
7. International Paper Co.
8. Buffalo and Niagara Falls Electric Light and Power Co.
9. The Niagara Falls Waterworks Co.
10. Niagara Research Laboratories.
11. Electrical Lead Reduction Co.
12. By-Products Paper Co.
13. Composite Board Co.
14. International Acheson Graphite Co.
15. The Carborundum Co.
16. Atmospheric Products Co
17. The Pittsburg Reduction Co.
18. Castner Electrolytic Alkali Co.
19. Niagara Electro-Chemical Co.
20. The United Barium Co.
21. Ampere Electro-Chemical Co.
22. Norton Emery Wheel Co.
23. Acetyvone Manufacturing Co.
24. Echota Disposal Works.
25. Ramapo Iron Works.
26. Roberts Chemical Co.
27. Oldbury Electro-Chemical Co.
28. Phosphorus Compounds Co.
29. Union Carbide Co.
30. Union Street Sub-Station.

Power House No. 1 and Transformer House.

Power House No. 1. Interior.

Power House No. 2.

Power House No. 2. Interior.

switchboard arrangements are different and in accordance with the most approved modern methods of construction.

In addition to power house No. 2, the Niagara Falls Power Co. is developing, through its allied company, the Canadian Niagara Power Co., 110,000 horse power on the Canadian side of the Falls. The hydraulic features of this development are very similar to those on the American side, which have proved so successful in operation. A wheel pit has been excavated in Victoria Park at a place about 1700 feet above the Horse Shoe Falls. Into this pit the water is discharged from a short intake canal and forebay, and carried off through a tunnel to the lower river.

The essential difference involved in this plant is in the size of the generating unit. The installation will consist of 11 units of 10,000 horse power each. When the power development was first started on the American side, a unit of 5000 horse power was selected as being a convenient subdivision of the total power development then contemplated, viz: 100,000 horse power. Now that more than 200,000 horse power is to be developed, a 10,000 horse-power unit can be installed and its relation to the capacity of the whole system will remain the same. Furthermore, great economy in cost of construction results in the use of this larger unit. A 10,000 horse-power turbine and dynamo occupy only slightly more space than one of 5000 horse-power capacity. This effects a considerable saving in length of power house, forebay, wheel pit, etc., for a given plant output. Also the cost of one 10,000 horse-power turbine and dynamo is less than the cost of two 5000 horse-power units. The advance in the art of turbine and dynamo manufacture in the last 10 years has been such that the construction of 10,000 horse-power machines now is not as difficult a problem as was that of the 5000 horse-power size when the first American power house was built.

The electric generators in the Canadian plant are wound for 11,000 volts, 3 phase. This voltage, which is 5 times as high as that of the American plant dynamos, was selected for reasons of economy in power distribution. This is about the highest voltage which is considered safe for underground distribution, and all the power will be taken out from the Canadian plant underground, necessarily, on account of the power house being in the Park.

For very long distance transmission, transformation will take place to a much higher voltage in a transformer station located on the plateau above the Park. Transformation will be made to 22,000, 40,000 or 60,000 volts, depending upon the transmission distance.

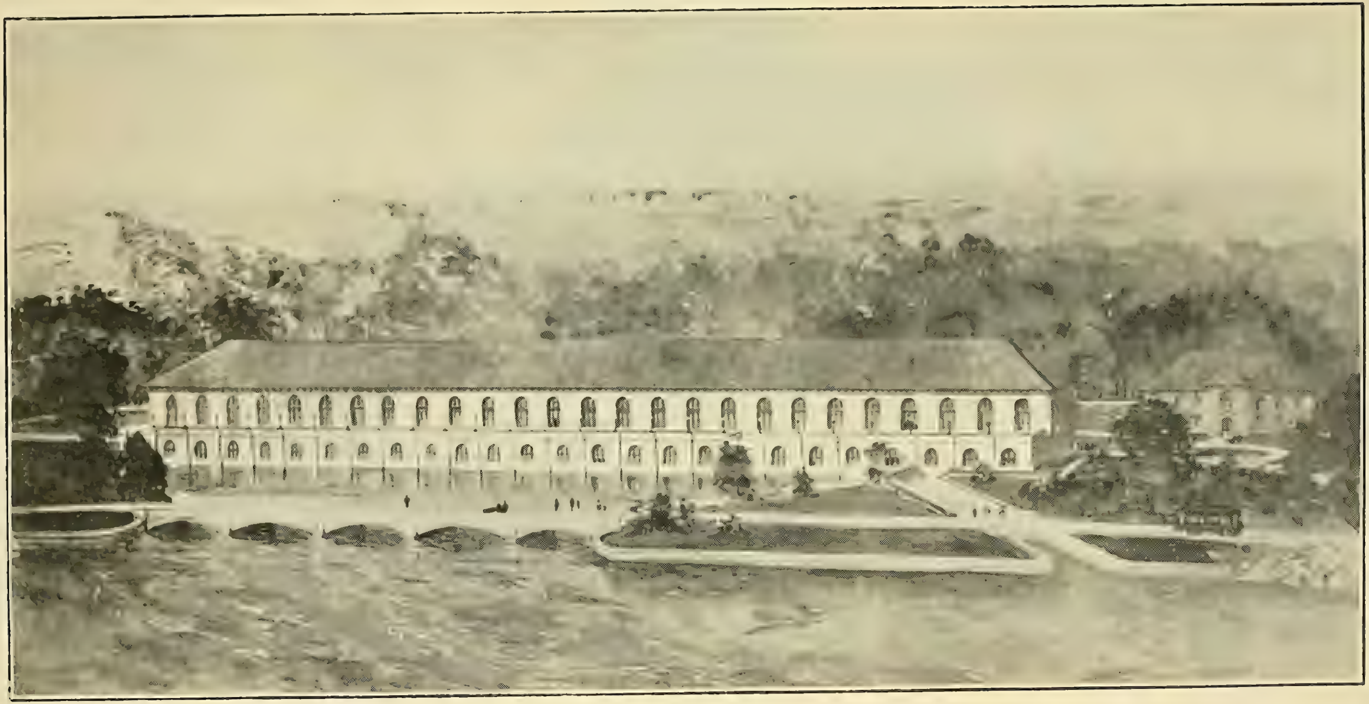
The Canadian plant will be electrically interconnected with both of the American power houses by cables across the upper steel arch bridge, so that 3 large independent generating stations will be available for the supply of power to the system of the Niagara Falls Power Co. This is a matter of the greatest importance to the Niagara frontier. In case of some unforeseen accident to any one of the plants, interconnections could at once be established so that the most important users of power, supplied normally by the disabled plant, could be supplied with power without interruption. This is especially important where the public utilities are involved, such as the electric railways and electric lighting companies.

One naturally asks where this 215,000 horse power is going to be used. The same question was asked in regard to the 50,000 horse power for which the first power house was constructed. The latter has been quickly answered by the fact that the load this winter exceeded 75,000 horse power. At the present rate of increase it will not be many years before the capacity of all 3 plants is reached.

The use of machine tools and mechanical processes in factories nowadays consumes a large amount of power, and the cost of power has therefore become a very important item to the manufacturer. It has made him investigate carefully the question of power cost, and the saving in this account which results from the use of power from the Niagara system as compared with that from an isolated plant. The central locality in the country of the Niagara frontier is also attracting attention in the industrial world, and I should not be surprised to see, during the next 10 years, a great influx of all classes of manufacturing concerns, attracted to this locality by the advantages named. Electro-chemistry is only just beginning to open up as an enormous user of electric power, and it is likely that many processes will be invented which will require the cheap power of Niagara to render them commercially operative.

All such industrial development means more homes and more people, which in turn require more electric lighting and more street railway traffic, which again increase the use of power. An enormous field for the use of Niagara power, which is only just beginning to open up, is the electric operation of the passenger and freight traffic on the great steam railroad trunk lines. In my opinion this is sure to come in the near future.

If you will draw a circle around Niagara Falls as a center, with a radius equal to about 100 miles, which might be considered as a fair limit of economical transmission under present electrical



Power House of Canadian Niagara Power Co.

conditions, and assume all the trains in this circle to be operated by Niagara power at approximately 500 to 1000 horse power per train, you will see the possibilities in this direction for the consumption of power from the Falls.

In spite of the possibilities for long distance transmission use, I believe, nevertheless, that the bulk of Niagara power will always be used within a radius of a few miles of the Falls. It is cheap power that the manufacturers want, especially those of electro-chemical products, and the nearer they get to the Falls the cheaper will be the power.

Transmission of power for long distances is expensive at best. Take the case, for instance, of the Niagara-Buffalo transmission. The current, after it leaves the generators, is transformed to 22,000 volts by expensive step-up transformers, which not only waste some of the power, but must be operated and maintained, and interest must be paid upon their cost. From here the current traverses the transmission line over a private right of way. This also must be operated and maintained, and interest must be paid upon a large investment in line as well as for right of way. Furthermore, power is lost in the transmission. After reaching the city line of Buffalo, the current is again transformed for distribution throughout the city. This distribution is accomplished by means of an extensive system of underground cables. All this apparatus must have fixed interest charges paid upon it and it requires a large force of experienced men for its operation. When, therefore, the statement is made that not over 10 per cent. is lost in transmitting power from Niagara to Buffalo, it does not mean that power will cost only 10 per cent. more in Buffalo than at the Falls; for the difference will be much greater than this.

However, even with this transmission cost added, Niagara power is delivered in Buffalo to-day to customers more cheaply than they can produce it themselves by isolated plants. The saving in cost is not the only advantage. The elimination of the steam boiler and engine outfit in a factory by the use of Niagara power is a luxury and a convenience which has many incidental commercial advantages.

When the Niagara enterprise was first started there was a great deal of talk about operating all the factories in New York State by Niagara power. Such a possibility, under the present state of electrical science, is theoretical only; for electric power, transmitted to such distances by present methods, could not possibly compete with steam. In theory, Niagara power can be sent to

San Francisco in any amount, but its cost, when it got there, would be prohibitive.

Another argument against transmitting Niagara power to a long distance from the Falls, is that it is not commercially necessary to do so. There will be probably a sufficient market for power within a 50-mile radius of the power house to use up all the power which has thus far been developed, and it is likely to continue so. It is cheaper for the factories to locate near the Falls than to carry the power a long way to the factories.

One exception to this general tendency against the transmission of Niagara power to long distances is in the case of the steam railroads mentioned above. If they change over to the use of electric power, it is likely that they will use Niagara power within a circle of wide radius about the Falls, possibly 100 to 150 miles. In their case the conditions are peculiarly favorable for long distance transmission. They will use power on a large scale, and will have their own private rights of way, without extra cost for the installation of their overhead circuits. Furthermore, they will have to compete electrically only with steam power as developed in the locomotive, which, as is well known, is a very expensive method of utilizing the energy of coal, as compared with a stationary engine.

At present the power distributed by the Niagara Falls Power Co. might be divided into 3 classes.

First. The local service to electro-chemical and other industries within the city limits of Niagara Falls. This at present aggregates about 45,000 horse power, divided among 30 industries. The largest users are the electro-chemical plants, which require current either for electrolysis or for the production of the very high temperatures obtainable in the electric furnace by which the reactions in their processes are brought about.

Second. The Canadian service across the upper steel arch bridge to industries and electric railroads in Canada, reaching as far as St. Catharines. This use is small at present, but it is the beginning of an industrial growth on the Canadian side of the river, which, in my opinion, will be very extensive in a few years. It now amounts to about 2000 horse power.

Third. Long distance service to Buffalo, Tonawanda, Lockport and Olcott, which now amounts to a total of about 30,000 horse power. In Buffalo approximately 24,000 horse power is used, divided among a very large number of customers, making use of the power for all kinds of purposes. This includes the power for operating the Buffalo street cars and the electric lights in the city.

In Tonawanda about 4000 horse power is used for railway, lighting and miscellaneous power purposes.

In Lockport the use amounts to about 1500 horse power for railway and miscellaneous purposes. Five hundred horse power is used at Olcott for operating one of the substations of the International Railway Co. This station is 39 miles from the Falls, which is at present the longest distance to which Niagara power is transmitted. All the freight on the International Railroad, between Olcott and Tonawanda, is handled by Niagara power by means of electric locomotives.

It is hoped that this brief outline will give an idea of the present status of the Niagara Falls Power Co. system. It represents, however, merely the beginning. In this country great cities have sprung up in certain localities for reasons far less important commercially than the conditions which exist on the Niagara frontier to-day. It is the center of population of the continent, approximately a focus of all the great trunk line railroads, and unlimited cheap power for manufacturing is available. It is also the eastern terminus of the Great Lakes' commerce. This latter, if the Niagara River is deepened, will be extended almost to the brink of the Falls themselves, affording 20 miles of sheltered dock front.

The day will come when we shall see a steamless city, reaching unbroken from Buffalo to the Falls, the industrial triumph of Niagara's power.

PROGRESS IN RAILROAD BRIDGE BUILDING.

By F. C. McMath, President of the Detroit Engineering Society.

[Address delivered at the Tenth Annual Banquet of the Society, April 29, 1904.*]

It is probably safe to say that nowhere in the world has the art of bridge building progressed faster than in the United States. Previous to 1860 practically all of our truss bridges were of timber construction—mainly of the Howe truss type. About this date the building of spans with cast-iron compression members and wrought-iron tension members became the fashion, and a few metal bridge building establishments sprang up; each concern usually adhering to some particular type of construction, such as the Fink truss or Bollman truss. It may interest the members of the Society to know that the old Detroit Bridge and Iron Works was one of these pioneer companies and built bridges under the Bollman patents. Metal bridges were something of a luxury in those days, the old records of the Detroit Bridge and Iron Works showing prices from 8 to 10 cents per pound. Not many railroads could afford metal structures at such figures, and combination wood and iron bridges began to be largely used, especially by the railroads in the West.

About 1880, bridges constructed entirely of wrought iron began to be commonly used. Seven or eight years later, steel eyebars were substituted for wrought-iron tension members, and about 1890 the iron compression members had to give way to those of steel.

The change from iron to steel was opposed by many engineers, but steel won the day on account of its lower cost.

During the period of change in the materials of bridge building, a very great change took place in the weight of rolling stock. In 1860 an ordinary locomotive and tender would weight about 40 tons; in 1880 a 66-ton engine was thought a monster. In 1890 engines of 100 tons were believed to be about the limit, but now there are plenty of engines weighing, with tender, 140 to 150 tons. These radical increases in loads naturally have had a marked effect on the bridge building industry. A bridge built for the loads of 1860 needed renewal about 1880, and structures designed for 1880 conditions had to come out before 1900. This is an understatement rather than an exaggeration. I know of one structure in Michigan that has been renewed no less than three times by one company. It is doubtful whether the limit in loads has yet been reached, but

* Manuscript received June 1, 1904.—Secretary, Ass'n of Eng. Socs.

this is a matter for the railroad engineers to worry about; not for the bridge builder to lose sleep over.

Pin-connected spans have been the favorite type in the United States from the earliest days of metal bridge building. Some years ago quite a controversy arose between American and English engineers as to the relative merits of pin and riveted spans, the latter being the distinctly English type. American engineers apparently had the best of the argument, the pin structures being unquestionably lighter in weight and cheaper to erect. In recent years, however, a strong tendency has set in toward the use of riveted structures for spans of short or moderate length. Most bridge engineers would not now use pin designs for spans less than 125 feet; and a few railroads, such as the New York Central Railroad, have practically cut out pin bridges altogether and are now making the riveted bridge their standard type. In Canada the riveted bridge has been in favor for some time by the leading railroad companies, being used quite generally for all spans up to 200 feet, whether single or double track.

There can now be no question that the English engineers were pretty much in the right in their old contention in favor of riveted bridges—at least for spans less than 200 feet, which cover the bulk of ordinary railroad structures. American engineers, however, have by no means copied English designs, even if they are coming around to the English type.

American designs use longer panels and much deeper trusses, and on this account our structures are lighter, stiffer, better and cheaper than the English. For some occult reason the English engineer feels that the slope of his diagonal truss members must be exactly 45°, if possible, and that the depth of truss must not exceed $\frac{1}{8}$ the span length. His adherence to these thumb rules makes his designs heavy and expensive, and, for short spans, often defective in their top chord bracing. They use difficult details, apparently taken from their shipbuilding practice, where probably there are good reasons for their use, for it must be admitted that they are masters of the art of shipbuilding.

During the past few years a marked improvement has been made in bridge floors. Timber floors are still in general use, but cross ties and guards are now much more substantial than formerly, and the space between the ties has been reduced from 8 inches or more down to 4 inches. Some of the trunk lines are abandoning timber floors altogether, and are using solid metal floors carrying gravel or rock ballast. These floors are exceedingly satisfactory in actual use, their great weight and rigidity reducing impact and

vibration to a minimum. The only objection to such floors lies in their higher first cost and liability to deterioration by rust. The most common type of solid floor is the trough floor, but it is expensive and very difficult to protect against rust. It may interest the Society to know that the cheapest and best type of solid floor is one designed by a member of this Society. It is in general use on the Michigan Central Railroad, and is being used to an increasing extent by other roads. A proper name for this type would be "the Douglas Solid Floor."

In the last two decades great progress has been made by the manufacturers of bridges. General methods and processes have shown no radical changes; but better system, more powerful machinery, pneumatic and electric handling devices, have reduced costs. Bridge shops have greatly increased in number and in capacity. Fifteen years ago no single concern had a capacity exceeding 2000 tons of bridge work per month. This output at the present time is far exceeded by many shops, and there is now a single plant with an estimated monthly capacity of 20,000 tons. This is the new plant recently completed by the American Bridge Company, at Ambridge, near Pittsburg. Some idea of the scale of the concern will be gained when it is known that provision has been made in the office for upward of 500 draughtsmen. Single pieces weighing 80 tons can be made and handled in this shop. Eyebars 16 inches wide can be made in the forge department.

Structures can be built to-day that would have been impossible a few years ago. This is the day of big things in bridge building, as well as in other lines of work. More huge bridges are under way than ever before. A 671-foot cantilever span is being built over the Mississippi River, at Thebes, Ill. The Wabash Railroad is about completing 2 huge cantilevers—one of 700 feet span over the Ohio, and one of 812 feet over the Monongahela River. At Quebec a cantilever span is being built over the St. Lawrence River, with a record-breaking span of 1800 feet. At New York a 1600-foot wire cable suspension bridge over the East River has been completed, and contracts have been let for a second bridge of cantilever construction, with a span of 1182 feet. Plans are under way for a third bridge of 1470 feet span, suspension type with eyebar cables.

In these last two structures, nickel-steel eyebars are to be used for the first time. The specifications for these bridges require full-sized annealed nickel-steel eyebars to have an ultimate tensile strength of not less than 85,000 pounds per square inch, whereas the minimum permitted for ordinary steel eyebars is only 56,000

pounds. It is thus apparent that the nickel-steel is about 50 per cent. stronger than the ordinary steel, a gain of enormous importance in bridge building. If nickel-steel can be supplied at reasonable figures, it will be widely used, especially in long spans.

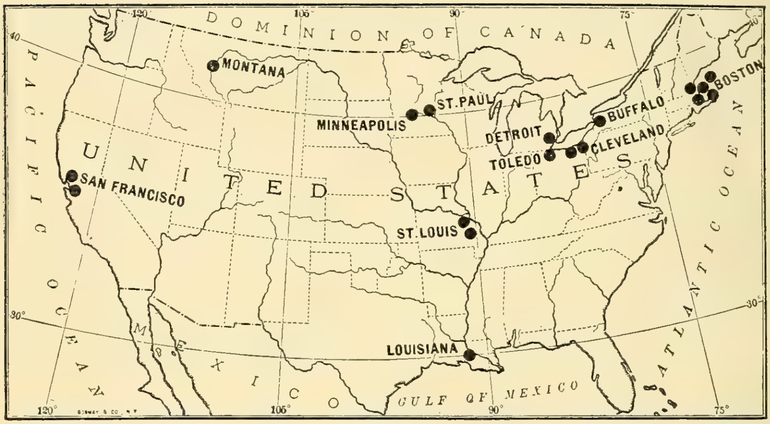
The former head of the United States Steel Corporation, Mr. Schwab, is evidently a believer in the future of nickel-steel, as he has cornered the supply of nickel. His concern, The Orford Copper Co., is now arranging for the rolling of a quantity of nickel-steel plates and angles with a view to having bridge shops try them under the ordinary processes of construction. If no unforeseen difficulties are encountered, it should be feasible to use, in long spans, nickel-steel for compression members as well as for eyebars.

Progress in bridge building has certainly been of great magnitude in the past, but there is still plenty of opportunity for further development and improvement. Some of the advocates of concrete-steel are prophesying the substitution of concrete-steel in place of steel girders for short railroad bridges, but the metal bridge builders are not yet particularly worried over prospective loss of this business.

There is yet much to be done in the way of standardizing bridge specifications. Various opinions are still held by engineers regarding the quality of steel to be used, loads to be provided for, and permissible unit strains.

Prof. Heller, of the Ohio State University, has recently made an interesting comparison of railway bridge specifications. He made a detailed comparison of about 30 railroad specifications, and found a surprising lack of uniformity. Selecting a certain member of the bottom chord of a 134-foot span, he found, under a given loading, the total stress to be 270,000 pounds. Using the averages of unit stresses of 28 different specifications, he found 25.4 square inches of metal required to resist this strain. The area required by the lightest specification was 11.4 per cent. below the average, whereas the heaviest specification required 18.6 per cent. more area, the total variation thus amounting to 30 per cent. He made similar calculations for the stringers of the same span, and found a total variation of 55 per cent. from the average.

Bridge designing is supposed to be one of the exact sciences, but it is very evident that there is no reason for bridge engineers to brag of exactness when their opinions of unit stresses vary to the extent shown above. It is to be hoped that, at some not very distant day, they will get together and adopt a standard specification. Strong efforts are now being made in this direction, and it is the devout wish of the bridge builder that they may be successful.



MAP

Showing the locations of the Societies forming

THE ASSOCIATION OF ENGINEERING SOCIETIES.

(Each dot represents a membership of one hundred, or fraction thereof over fifty.)

ASSOCIATION OF ENGINEERING SOCIETIES.

VOL. XXXII. JANUARY, 1904. No. 1.

PROCEEDINGS.

Engineers' Society of Western New York.

ANNUAL MEETING, BUFFALO, N. Y., DECEMBER 21, 1903.—The meeting was held in the rooms of the Society, 533 Ellicott Square, on Tuesday, December 1, 1903, Vice-President Norton in the chair.

Mr. Geo. B. Bassett was appointed to examine the reports of the Secretary and the Treasurer.

The reports of the officers were received. The meeting then proceeded to count the ballots for officers. The Vice-President declared that the following persons were elected:

President—Chas. E. P. Babcock.

Vice-President—Thomas W. Wilson.

Director (for one year)—Samuel J. Dark.

Director (for three years)—Louis H. Knapp.

Secretary—Harry B. Alverson.

Treasurer—Frank N. Speyer.

Librarian—William A. Haven.

The meeting then adjourned to meet at 8 o'clock in the evening, at the University Club. At the adjourned meeting about fifteen members were present, and during the evening they discussed the state of the Society and suggested various plans for its improvement, and adjourned at midnight.

(Signed) LEE W. EIGHMY, *Secretary.*

ANNUAL REPORT OF THE SECRETARY, 1903.

To the President and Members of the Engineers' Society of Western New York:

I submit the following annual report for 1903:

Total Membership, December 1, 1902	84
Total membership, December —, 1903	83
Consisting of:	
Honorary member	1
Members	65
Associates	13
Juniors	4

MONEYS.

Amounts received December 1, 1902, to December 1, 1903:

For entrance fees	$40.00
For dues	493.75
For key deposits	.75
For JOURNAL advertisements	50.00
For annual dinner fees	2.00
For extra printed copies of paper on "Metric System"	5.00
Total	$591.50
Amount deposited with the Treasurer, 1903	$591.50

The Society has held eight meetings during the last year, at which the following papers were presented:

January.—"Abatement of the Smoke Nuisance in the City of Buffalo"—report of special committee—read by Mr. Louis H. Knapp.

February.—"Hydraulic Questions of the Proposed Buffalo River Improvement," by Mr. Geo. H. Norton.

March.—"Track Construction of the International Railway Company in Buffalo," by Mr. Thos. W. Wilson.

April.—"Good Roads," by Mr. George C. Diehl.

May.—"Value of Inspection," by Mr. Walter H. Golden.

June.—"Telephony," by Mr. Wilbur H. Johnson.

October.—"Observations on the Littoral, Easterly End of Lake Erie and Head of Niagara River," by Dr. Geo. E. Fell.

There was no quorum at the September meeting and no literary program for the November meeting, which was held on the night of "Election," and it has been suggested that the November meeting date be changed on this account.

A paper was read before the Society at every meeting except this one. The average attendance has been twelve. That was also the average attendance for 1902, during which four papers were presented. Mr. Roberts, the Secretary for that year, suggested, in his annual report, that if more papers could be had, the attendance would be increased; this is not borne out by the record.

Twelve meetings of the Executive Board have been held since December 1, 1902, with an average attendance of five.

One amendment was made to the Constitution, viz: To allow all classes of membership to vote and hold office.

I would respectfully request that the President appoint a committee to examine my books before I turn them over to the newly elected Secretary.

(Signed) L. W. EIGHMY, *Secretary.*

ANNUAL REPORT OF TREASURER.

Engineers' Society of Western New York.

GENTLEMEN:—As your Treasurer, it is my pleasure to submit the following report:

RECEIPTS.

From G. B. Bassett, retiring Treasurer	$294.41
From the Secretary and others	571.60
From banks, interest	10.53
Total	$876.54

DISBURSEMENTS.

Rent, October, 1902, to September, 1903, inclusive	$276.00
Three quarterly assessments, A. E. S.	93.50
Postage, printing and stationery	93.32
Binding, magazines, etc.	24.60
Subscriptions for magazines, etc.	15.20
Stenographer, typewriting, annual dinner and sundries	55.58
Erie County Bank Fund	311.10
Fidelity Bank Fund	7.24
	$876.54

BALANCE ON HAND.

General Fund	$6.14
Library Fund	72.30
Permanent Fund	239.90
	$318.34

Respectfully,
(Signed) F. N. SPEYER, *Treasurer.*

REPORT OF THE LIBRARIAN.

To the Engineers' Society of Western New York:

The following-named periodicals, magazines, transactions, reports, etc., are regularly received and placed on the shelves:

"American Society of Civil Engineers." (Transactions.)
"American Society of Mechanical Engineers." (Transactions.)
"American Institute of Electrical Engineers." (Transactions.)
"Anales Del Instituto De Injenieros De Chile."
"Association of Engineering Societies." (Journal.)
"Association of Civil Engineers of Cornell University."
"Canadian Society of Civil Engineers." (Transactions.)
"Cassier's Magazine."
"Engineers' Club of Philadelphia." (Proceedings.)
"Engineering News."
"The Dirt Mover."
"The Engineering Magazine."
"Engineers' Society of Western Pennsylvania." (Proceedings.)
"Engineering Index."
"Mineral Survey of the State of Texas."
"Municipal Journal and Engineer."
"Popular Mechanics."
"Railroad Gazette."
"Railway and Engineering Review."
"Railroad Herald."
"State Engineer of New York." (Reports.)
"Street Railway Journal."
"United States Consular." (Reports.)
"United States Geological Survey." (Reports.)
"United States Chief of Engineers." (Reports.)
"United States Coast Survey." (Reports.)
"United States Department of Agriculture on Forestry." (Reports.)
"United States Water Supply and Irrigation." (Reports.)
"Western Society of Engineers." (Transactions.)
"Wisconsin University." (Bulletins.)

As soon as full volumes of these are issued they are bound and placed on the shelves.

In addition to the above, a good many other periodicals are sent to us at irregular times, all of which are preserved for reference.

There are now on the shelves 380 bound volumes and 290 pamphlets. Sixty volumes of periodicals are ready for binding as soon as the finances will admit. Besides these there are in the library upwards of 500 pamphlets, periodicals, transactions, specifications, maps, plans, etc.

There is a complete file of bound volumes of *Engineering News*, with the exception of nine volumes between 1885 and 1891; three of these are complete, with the exception of one number in each volume, which the librarian has been trying for six months to acquire by purchase.

Through the kindness of our members we receive at the close of each year a large number of periodicals, so that we have on hand many duplicates, which are for sale or exchange.

During the past year there has been expended for the library the following sums, viz:

For binding books	$24.60
For subscriptions and sundries	13.07

Respectfully submitted,

W. A. Haven, *Librarian.*

Civil Engineers' Club of Cleveland.

The rooms of the Civil Engineers' Club, in the Arcade, were filled almost to overflowing Tuesday, January 12th, in honor of President Walter C. Parmley, of the Club, the regular meeting being followed by an informal reception to Mr. Parmley, who will leave the city next week to become general manager of the New York Cement Company, with offices in New York City.

Mr. Parmley was elected to the Presidency of the Club last March, and had all but completed his term. He leaves Cleveland, after having been connected with the City Engineer's office since 1896, as engineer of the intercepting sewer system, which is now designed and partially completed. In addition to the management of the New York Cement Company, which is engaged in the manufacture of cement building stones, Mr. Parmley will continue the designing and constructing of concrete and steel engineering work.

At the reception appropriate speeches of regret, congratulation and eulogy were delivered by Robert Hoffman, Mr. Parmley's successor in the City Engineer's Office; ex-City Engineer M. E. Rawson and others, and were replied to by Mr. Parmley. A buffet luncheon was served at a late hour.

The following Nominating Committee for officers for the ensuing year was elected: M. E. Rawson, J. H. Fox, Jas. Ritchie, A. A. Honsberg, A. A. Skeels, G. T. Nelles and W. P. Brown.

Joe C. Beardsley, *Secretary.*

Engineers' Club of St. Louis.

571ST MEETING, ST. LOUIS, MO., DECEMBER 16, 1903.—The annual dinner of the Club was held at the Washington Hotel, President Van Ornum presiding. There were forty-seven members and thirteen guests present.

After the dinner the Club was called to order by the President, who announced the result of the ballot for officers for the year 1904, as follows:

President—J. A. Ockerson.

Vice-President—Robert Moore.

Secretary—R. H. Fernald.

Treasurer—E. E. Wall.

Librarian—E. B. Fay.

Directors—J. L. Van Ornum and E. A. Hermann.

Members of Board of Managers of Association of Engineering Societies —F. E. Bausch and W. C. Toensfeldt.

The President then announced that the annual prize for the best paper read during the year ending July 1, 1903, had been awarded to Mr. C. D. Purdon for his paper on "Railway Grade Reduction," read before the Club, May 6, 1903.

The address of the retiring President, J. L. Van Ornum, upon "Fable and Fact as Factors of Progress," was then presented, and was followed by appropriate remarks by the newly-elected President, J. A. Ockerson, who acted as toastmaster for the evening.

Remarks, both serious and far from serious, were then offered by various members of the Club, including Messrs. Philip Moore, John Laird, R. H. Phillips, C. A. Moreno, L. F. Goodale and others.

Although Rear-Admiral George M. Melville, U. S. N., and Lieut. Godfrey L. Carden, who were to respond to toasts, were unable to be present, much pleasure was given by the remarks of other guests of the evening, namely, Dr. Tarleton H. Bean, Chief of the Department of Forestry, Fish and Game; Col. F. M. De Sousa Aguiar, President of the Brazilian Commission to the Louisiana Purchase Exposition, and Mr. Wong Kai Kah, Vice-Commissioner to the Exposition from China. The remarks of the last-named speaker upon engineering conditions in China, past, present and future, awakened more than ordinary interest and enthusiasm.

R. H. FERNALD, *Secretary.*

572D MEETING, ST. LOUIS, MO., JANUARY 6, 1904.—Held at the Club Rooms, 709 Pine Street, at 8.15 P.M.; President Ockerson in the chair. Present, thirty-five members and eight guests.

The minutes of the 570th and 571st meetings were read and approved, and the minutes of the 359th meeting of the Executive Committee were read.

The question of the continuation of lunches, with the lunch fund showing a deficit, was discussed. Upon motion of Mr. Bryan it was decided to discontinue the lunches until such time as the profits from the *Bulletin* or other sources (not the regular general funds) shall warrant their continuation.

The President was authorized to appoint a committee to prepare a suitable memorial on the death of Mr. George W. Fisher, a charter member of the Club.

The following committees were appointed by the President:

Members of Governing Board of the Associated Technical Clubs of St. Louis—A. H. Zeller and F. E. Bausch.

Committee on Smoke Prevention—Philip N. Moore, Edward Flad, H. H. Humphrey, E. C. Parker and N. W. Perkins.

Committee on Entertainment—F. E. Bausch, T. M. Post and S. E. Freeman.

The paper of the evening, on "Vital Statistics of St. Louis Since 1840," was presented by Mr. Robert Moore. Mr. Moore gave a most interesting account of the causes of varying percentages in the yearly death rate; he showed conclusively the continued decrease in the death rate since 1840, as indicated by the following figures:

TOTAL DEATH RATE PER 1000.

1841-50.	1851-60.	1861-70.	1871-80.	1881-90.	1891-1900.
51.47	40.84	30.33	22.26	20.51	18.74

Tables and charts showing the deaths caused by consumption and typhoid fever and the death rate of children under five years of age brought out many important facts, and the relations between the number of deaths from typhoid fever and the opening of certain sewers in St. Louis were clearly demonstrated.

The discussion which followed the reading of the paper was participated in by Messrs. Flad, Wheeler, Ockerson, Turner, Johnson, Humphrey, Swope and others.

Adjourned. R. H. FERNALD, *Secretary.*

573D MEETING, ST. LOUIS, MO., JANUARY 20, 1904.—The meeting was held at the Club Rooms, 709 Pine Street, at 8.15 P.M.; President Ockerson in the chair. The minutes of the 572d meeting were read and approved.

Mr. Sherman Worcester Bowen was elected to membership. The President appointed Mr. P. N. Moore, Mr. W. A. Wise and Mr. R. E. McMath as a committee to prepare a suitable memorial on the death of Mr. G. W. Fisher.

Applications for membership were read from Mr. H. H. Morrison, Mr. F. H. Vose and Mr. P. R. Goodwin.

Mrs. S. B. Russell, Chairman of the World's Fair Committee, presented a report embodying the following recommendations:

That a young engineer be installed at the rooms of the Club from May 1 to December 1, 1904, to greet and welcome visiting engineers and give them such directions as would enable them to reach the points of local interest they might wish to see. Also, that a Bell telephone be installed in the rooms of the Club, and that an effort be made to induce the two architectural societies sharing the Club Rooms to share the expense.

That the Club be requested to authorize the committee to call on volunteers from the Club to assist in meeting and entertaining visiting engineers.

That the committee recommend the preparation of a pamphlet consisting of four sections, as follows:

"World's Fair Section."
"Engineering Guide to St. Louis and Vicinity."
"Local Engineering Data."
"Engineers' Club Bulletin."

Upon motion of Professor Van Ornum, the Club indorsed the plan outlined by the committee.

The paper of the evening, upon "International Morality and the Panama Question," was then presented by Prof. Arthur O. Lovejoy, Professor of Philosophy at Washington University.

In showing the action of the United States Government to be justified, the following points were brought out by the speaker: Has one part of a country the right to secede? Morally, opinion is generally in favor of the right of secession, but this may be easily counterbalanced by reasons, such as geographical conditions, manners, etc., of the different peoples forming the whole. . . . . Panama has long been the cow which Colombia has milked, by taxes, etc. United States intervention was a good thing to the people of that country, and to the whole world, because of its final consequences. Compare United States intervention in the Panama question with the aid rendered this country by France in the War for Independence.

There is a moral right to intervene where what happens in the back yard of a neighboring nation affects the health and well-being of a nation. Inasmuch as there is no power with the right of eminent domain, then the strong powers can and should, if with pure intentions, intervene, to see that the country doing a wrong to the whole is restricted for the benefit of the majority. In the Panama question it is right that the canal should be open for the use of the world by the nation through whose territory it passes, and if that nation refuses to permit another nation to do that work for it under reasonable conditions and offer a very liberal indemnity, is there not an international right of eminent domain morally?

Mr. Robert Moore discussed the paper at son e length, bringing out many points of interest. He said, in part:

"If we look at this matter in the light of general welfare, either our own, or Panama, or the whole of South America, that there was no justification whatever on the part of the Government of Colombia for blocking the way as they intended to do, and still less justification when we take into account the very obvious reason for the delay in order to extort a larger price from the United States, both by virtue of the lapse of the franchise of the Frenchmen and the proportion which we offered to the Frenchmen of $10,000,000, I think the whole matter entirely justified on the whole ground of the interest of America and of right. . . . . The whole talk of the Panama secession as a speculation of a lot of gamblers is extremely silly as affecting the United States in the case."

The Club was pleasantly entertained by the remarks of one of the guests of the evening, Mr. A. Q. Prada, of Colombia, who took exceptions to the views previously presented. The following points were brought out: No man can find anything that would indicate that Panama was disgusted with Colombia. It was an independent State with its own laws. One State cannot oppress another while both States have equal rights. . . . . Colombia has never done anything to mar her standing as a nation, and she is to-day one of the most promising republics in the world, taking into account her short political existence of eighty odd years and the question of how many things Colombia has accomplished. . . . . The treaty, as written and prompted by the United States at Washington, was not acceptable to Colombia, as Constitutional objections were involved. The Bogota Government, upon refusing the treaty, did not intend to quash proceedings and prevent the United States from building the canal. She

was willing to make a treaty more satisfactory to both parties. The treaty with France did not involve the questions; the treaty with the United States did. France was willing to take a concession for ninety-nine years. The United States did not want anything but perpetual sovereignty, which the Colombian Constitution prohibited. The United States would feel affronted if a European country offered to buy a part of its territory. Colombia felt the same way. They did not wish to dismember their country. If the United States had been willing to build the canal under the French proposition, the canal would to-day be nearly completed. But the United States wanted too much: wanted the territory itself, which Colombia would not assent to.

The paper was further discussed by Professor Van Ornum, Mr. Ernest McCullough and Mr. Robert Burgess, the last speaker stating that: "In some three weeks in the city of Panama, in talking with people and their acquaintances, I got the impression that Panama was very closely tied to the rest of the country, but they did not feel that they really belonged to it. They are almost universally in favor of the new government."

A vote of thanks of the Club was extended Professor Lovejoy and the gentleman from Colombia (Mr. A. Q. Prada) for their interesting and instructive addresses.

Adjourned. R. H. Fernald, *Secretary.*

Technical Society of the Pacific Coast.

Regular Meeting, San Francisco, Cal., December 4, 1903.—Called to order at 8.30 p.m. by President D. C. Henny.

The minutes of the last regular meeting were read and approved.

The following names were elected to membership: Joseph Jacobs, civil engineer; Robert Hauxhurst, Jr., civil engineer; M. C. Couchot, civil engineer; and instructed to be added to the list.

The election of a Nominating Committee to select a ticket of officers for the ensuing year being in order, the following members were chosen and elected in due form, and the Secretary was instructed to notify them of their election and their duties: Chas. D. Marx, chairman; Marsden Manson, F. C. Herrmann, Hermann Barth and Hermann Kower.

The adoption of the resolutions to amend the By-laws to the extent of confining the meetings of the Society to two during the year, as recommended by the committee at the last November meeting, and there read for the first time to be ratified and approved at the December meeting, was then taken up in regular form.

The Secretary read the amendments as proposed, and the Society acted upon each individually, retaining the general proposition embodied in the recommendation, but introducing alterations in minor details, adopting by vote the amendments in regular order, as follows:

A—Strike out Section 2, Article I, of the By-laws, which reads:

"Section 2. The regular stated meetings of the Society shall be held on the first Friday of each month, at the hall of the Society, at 8 p.m."
and substitute therefor:

"The regular stated semi-annual meetings of the Society shall be held as follows: One, the spring meeting, either in April or May, and the other,

the fall meeting, either in September or October of each year, the precise date and place of meeting to be left to the discretion of the Board of Directors, who shall arrange a program and announce such date and place at least thirty days before the meeting, which is to be held for the purpose of reading and discussing technical papers, as well as for stimulating professional and social intercourse among members."

B—Amend Section 3, Article I, by placing before the present section the following words:

"Monthly stated meetings may be held on the first Friday of any month, excepting that of July, for the transaction of the ordinary business of the Society and for informal topical discussions."

C—Strike out all of Section 5, Article I, which would be in conflict with Section 2 as now amended.

Amendments A, B and C, as here recorded, were approved by vote, and the Secretary was instructed to incorporate them in the By-laws.

No further business appearing, the meeting adjourned.

Otto von Geldern, *Secretary.*

Regular Meeting, San Francisco, Cal., January 2, 1904.—Called to order at 8.30 P.M. by Past-President Dickie.

The minutes of the last regular meeting of December were read and approved.

The Secretary of the Nominating Committee reported as follows:

San Francisco, December 26, 1903.

Your Committee on Nominations of Officers for the ensuing term desires to make the following report:

For President—Geo. W. Dickie.

For Vice-President—Franklin Riffle.

For Secretary—Otto Von Geldern.

For Treasurer—E. T. Schild.

For Directors—C. E. Grunsky, L. J. Le Conte, H. D. Connick, Adolf Lietz and Carl Uhlig.

Respectfully submitted,

F. C. Herrmann, *Secretary of Committee.*

The Secretary was instructed to prepare these names for ballot, in time for the annual meeting to be held January 22, 1904, and the Chairman appointed the following tellers: George H. Wallis and Leon S. Quimby.

Past-President Dickie explained at length a movement on foot by the Chamber of Commerce of London to carry on an extensive course of technical lectures in the principal cities of the United States. These lectures are elaborately prepared and illustrated by numerous costly lantern slides, and touch upon almost every field of technical activity. The expenses are to be borne by Mr. Morgan, including the renting of the hall for the purpose and the apparatus for illustration. Mr. Dickie desired to know whether the Society would agree to entertain any proposition encouraging the holding of these lectures which would be absolutely without any expense; the matter had been laid before him by men prominently connected with this enterprise, and he asked whether any inducements would be held out by the Technical Society to give it its support.

Colonel Wallis thought the idea a very good one and suggested that

the Society agree to hold this course of lectures in San Francisco under its auspices, and moved that Mr. Dickie inform the patrons that the Technical Society, being desirous of encouraging and supporting this movement, agrees to hold these lectures in its name and under its protection at any future time, and in any manner that the new Board of Directors, who are about to go into office, may deem expedient and desirable. The motion was carried.

The meeting thereupon adjourned.

Otto von Geldern, *Secretary.*

Annual Report of the Secretary for the Year 1903.

I have the honor to submit to the Society, through its Board of Directors, the following report, showing the condition of the Society on January 22, 1904, the date of the regular annual meeting:

The present total membership is 158, as follows:

Honorary members	2
Life members	3
Members	136
Associates	17
Total	158

Of these there are:

Resident members	86
Resident associates	55
Non-resident members and associates	17
Total	158

Geographically distributed there are in:

San Francisco and vicinity	107
Northern California	26
Southern California	5
Arizona	1
Colorado	1
District of Columbia	1
Hawaii	3
Illinois	1
Massachusetts	1
Nevada	2
New York	1
Oregon	2
Washington	1
Utah	1

FOREIGN.

Australia	1
Africa	2
British Columbia	1
England	1
Total	158

Professionally divided there are:

Architects	8
Builders	10
Chemists	2
Civil Engineers	65
Draughtsmen	4
Electrical Engineers	5
Instrument Makers	2
Manufacturers	7
Mechanical Engineers	27
Military Engineers	3
Mining Engineers	9
Naval Architect	1
Professors of University	5
Scientist	1
Surveyors	9
Total	158

ADMISSIONS IN 1903.

By election:	
Members	10
Associates	3
By reinstatement:	
Members	6
Total	19

MEMBERSHIP OF THE SOCIETY AT THE END OF THE YEAR 1902.

Members and associates	153
Admitted in 1903	19
Total on membership list during the past year	172

LOSS DURING THE YEAR 1903.

Deaths	3
Resignations	8
Suspensions	3
Total loss	14
Carried on membership list during 1903	172
Loss	14
Present membership	158
Gain in 1903	5

DEATHS DURING 1903.

George F. Allardt,
Dana Harmon,
F. B. Morse.

During the year the Society added to it's membership the following: By election:

MEMBERS.

1. M. C. Couchot, Civil Engineer, San Francisco, Cal.
2. Robert Hawxhurst, Jr., Civil Engineer, Hawaii.
3. L. A. Hicks, Civil Engineer, Oakland, Cal.
4. Joseph Jacobs, Civil Engineer, San Francisco, Cal.
5. August Kempkey, Jr., Civil Engineer, Oakland, Cal.
6. Charles List, Civil Engineer, San Francisco, Cal.
7. R. W. Myers, Electrical Engineer, San Francisco, Cal.
8. George W. Nichols, Electrical Engineer, Round Mountain, Cal.
9. Oliver N. Sanford, Civil Engineer, San Francisco, Cal.
10. J. J. Welsh, Architect, San Francisco, Cal.

ASSOCIATES.

1. S. Giletti, Concrete Builder, San Francisco, Cal.
2. George Stone, President Pacific Portland Cement Co., San Francisco, Cal.
3. Rudolph J. Taussig, President Mechanics Institute, San Francisco, Cal.

By reinstatement:

MEMBERS.

1. Gustav A. Behrnd, Architect, San Francisco, Cal.
2. H. L. Demeritt, Civil Engineer, San Francisco, Cal.
3. H. F. Eckert, Structural Engineer, San Francisco, Cal.
4. Franz M. Goldstein, Draughtsman, San Francisco, Cal.
5. F. A. Koetitz, Civil Engineer, San Francisco, Cal.
6. James T. Ludlow, Mechanical Engineer, San Francisco, Cal.

RESIGNATIONS DURING THE YEAR 1903.

1. Ross E. Browne, Mining Engineer, South Africa.
2. Thomas W. Butcher, Builder, San Francisco, Cal.
3. B. C. Donham, Civil Engineer, Korea.
4. John McGilvray, Builder, San Francisco, Cal.
5. Erland Gjessing, Stenographer, New York, N. Y.
6. Frank H. Masow, Builder, San Francisco, Cal.
7. A. S. Riffle, Civil Engineer, Arizona.
8. Charles E. Wetherell, Surveyor, San Francisco, Cal.

SUSPENSIONS DURING THE YEAR 1903.

1. J. B. Crockett, San Francisco, Cal.
2. O. H. M. Denio, Vallejo, Cal.
3. Peter E. Lamar, Hawaii.

HONORARY MEMBERS.

1. Colonel C. Seaforth Stewart, Washington, D. C.
2. Commodore Theodore D. Wilson, Washington, D. C.

LIFE MEMBERS.

1. George W. Dickie, San Francisco, Cal.
2. George H. Evans, Breckenridge, Col.
3. E. J. Molera, San Francisco, Cal.

The following subjects were read and discussed officially during the past year:

1. "The Water and Forest Irrigation Bill," by the Society.

2. "Armored Concrete Piles and Wharves," by Emile Villet.

3. "The Giletti System of Concrete and Iron Construction," by S. Giletti.

4. "Building of an Iron Wharf at Ocos, Guatemala," by Charles List.

5. "Description of the Holmes and Uhlig Method of Wharf Building," by Carl Uhlig.

6. "The Work of the United States Department of Agriculture in Irrigation Investigation," by Elwood Mead.

7. "Projects for a Water Supply for the City of San Francisco," by Marsden Manson and C. E. Grunsky.

8. "Impressions Made by Recent Engineering Works of the East," by C. E. Grunsky.

9. "Methods of Refrigeration," by James T. Ludlow.

10. "Regarding Patent Laws and Their Necessity," by George W. Dickie.

11. "The Administration of Patent Laws," by John Richards.

12. "Amending the By-laws as to Frequency of Meetings and Regulating Semi-annual Meetings of the Society, Committee and Society at Large."

13. "The Works of the Pacific-Portland Cement Company at Suisun, and Excursion to the Works by the Society."

OTTO VON GELDERN, *Secretary.*

Boston Society of Civil Engineers.

BOSTON, MASS., JANUARY 14, 1904.—A special meeting of the Boston Society of Civil Engineers was held at Chipman Hall, Tremont Temple, at 8 o'clock P.M., Vice-President Frederick Brooks in the chair; one hundred and two members and visitors present.

Mr. George B. Francis presented two papers, which were fully illustrated by lantern views. The first paper was on "Timber Crib Foundations," and was discussed by Messrs. J. W. Rollins, J. P. Snow, William Parker and others. The second paper read was entitled "Description of the Construction of a Double-Track, Third-Rail Electric Road between Scranton and Wilkesbarre, Pa."

S. E. TINKHAM, *Secretary.*

BOSTON, MASS., JANUARY 27, 1904.—A regular meeting of the Boston Society of Civil Engineers was held at Chipman Hall, Tremont Temple, at 7.30 o'clock P.M., President Hollis in the chair; one hundred and twenty-two members and visitors present, including ladies.

The records of the last regular and the special meeting of January 14th were read and approved.

Messrs. William W. Locke, J. Waldo Smith and George Stephen were elected members of the Society.

On motion of Mr. Manley, the President was requested to appoint a committee of three to report to the meeting the names of five members to serve as a committee to nominate officers for the ensuing year. The President appointed the following as that committee: Henry Manley, F. C. Coffin and Leonard Metcalf.

Later in the meeting this committee reported the following names as members of the Nominating Committee: Messrs. A. H. French, C. T. Main, George Bowers, H. K. Higgins and J. L. Howard, and on motion they were duly elected.

The Secretary reported for the Board of Government that at a meeting of the Board, held December 21, 1903, under authority of By-law 15, it was voted to establish the Sanitary Section of the Boston Society of Civil Engineers, in accordance with the petition of Freeman C. Coffin and thirteen other members of the Society.

The Section has held one or more meetings and has adopted the following code of By-laws, which has been approved by the Board:

ARTICLE I.

SECTION 1. The object of the Sanitary Section of the Boston Society of Civil Engineers shall be the advancement of knowledge relating to the science and practice of sanitary engineering.

ARTICLE II.

SECTION 1. The membership of the Sanitary Section shall consist of members and associates.

SEC. 2. Those engaged in the design, construction or maintenance of sanitary works, or other persons qualified to aid in the advancement of knowledge relating to the science and practice of sanitary engineering shall be eligible as members.

SEC. 3. Other persons interested in the objects of the Section and desirous of being connected with it shall be eligible as associates after election as associates in the Society.

SEC. 4. Members only shall be eligible to office and entitled to the right to vote.

ARTICLE III.

SECTION 1. Members and associates of the Boston Society of Civil Engineers shall be entitled to membership in this Section as members and associates, respectively, upon making written application to the Executive Committee of the Section.

SEC. 2. Any person other than a member of the Boston Society of Civil Engineers who shall make application for admission to the Section as member shall embody in his application a concise statement of his qualifications for membership, and his application shall be indorsed by two members of the Section.

SEC. 3. Applications for membership under section 2 shall be considered by the Executive Committee, who shall present them to the Board of Government of the Society, provided a majority of the committee are in favor of such action, and if the applications are approved by the Board of Government they shall be presented to the Section for ballot.

SEC. 4. If the applicant receives two-thirds of the ballots cast, he shall be declared elected, and shall become a member on paying the required entrance fee and signing, within two months, an agreement to be governed by the By-laws of the Section and the Constitution and By-laws of the Society so far as they apply to the Section.

SEC. 5. Members and associates of the Boston Society of Civil Engineers, who are not enrolled as members of the Section, shall be entitled to attend all meetings of the Section and to take part in the discussion of papers on professional subjects, but shall have no vote.

ARTICLE IV.

SECTION 1. The officers of this Section shall be a Chairman, Vice-Chairman and Clerk.

The general government of the Section shall be vested in an Executive Committee, consisting of the President of the Boston Society of Civil Engineers, the Chairman, Vice-Chairman, Clerk and three other members of the Section.

SEC. 2. The Chairman of the Section shall represent the Section at the meetings of the Board of Government of the Boston Society of Civil Engineers, with the privilege accorded under its By-laws.

SEC. 3. The term of office of all officers and committees shall be one year, but shall continue until their successors are elected.

SEC. 4. All officers and committees shall assume their duties immediately after the close of the meeting at which they have been elected.

ARTICLE V.

SECTION 1. The Chairman shall have a general supervision of the affairs of the Section. He shall preside at meetings of the Section. In case of his absence or a vacancy in his office, the Vice-Chairman shall discharge his duties.

SEC. 2. The Executive Committee shall have control of the management of the Section, subject to the action of the Section at any meeting, and shall make the necessary arrangements for all meetings. All questions in Executive Committee shall be decided by a majority vote, and four members shall constitute a quorum. Meetings of the Executive Committee shall be held before each business meeting of the Section and at the call of the Section Chairman, or in his absence or inability to serve, at the call of the Vice-Chairman.

SEC. 3. The Clerk shall keep the records of the meetings of the Section and of the Executive Committee, and perform such other duties as are herein prescribed and as may be required by the Executive Committee. He shall prepare and transmit to the Secretary of the Boston Society of Civil Engineers notices of all meetings, copies of the records of all meetings and of all papers and discussions.

SEC. 4. No expenditure shall be made or financial obligation incurred by any officer or committee of the Section, for which the Society will be responsible, without previous authorization by the Board of Government or President of the Society.

ARTICLE VI.

SECTION 1. The annual meeting of the Section shall be held in Boston on the first Wednesday in March, at which meeting the annual reports for the preceding year shall be presented and the officers for the ensuing year elected.

SEC. 2. The officers and other members of the Executive Committee shall be elected at this meeting by written ballot, from nominations made from the floor, or submitted in writing previous to the meeting and indorsed by at least ten members.

SEC. 3. The regular meetings of the Section shall be held on the first Wednesday of the months of March, June, October and December.

SEC. 4. Special meetings of the Section may be held at the call of the Chairman. At special meetings no applications for membership shall be acted upon, nor any business transacted, unless announced in the call for the meeting and upon recommendation of the Executive Committee.

ARTICLE VII.

SECTION 1. Proposed amendments to these By-laws must be submitted in writing to the Executive Committee, and shall be presented to the Section at a regular meeting, if so decided by vote of the Executive Committee. The Executive Committee shall, however, bring before the Section any proposed amendment at the written request of ten members.

SEC. 2. Announcement of a proposed amendment which is recommended by the Executive Committee or by ten members of the Section, shall be given by printing the amendment in the notice of the regular meeting. A two-thirds vote of the members present and voting shall be necessary for the adoption of the amendment.

SEC. 3. All amendments to these By-laws must receive the approval of the Board of Government of the Boston Society of Civil Engineers before taking effect.

Mr. F. W. Hodgdon submitted the following motion, which had been printed in the notice of the meeting: Voted, that the Society indorse and recommend the changes in the Boston Building Laws proposed by

the Committee of the Society in its report made at the meeting held December 16, 1903; and that the same committee be instructed to take the necessary action to submit the proposed changes, with the indorsement of the Society, to the Mayor, and to appear in behalf of the Society, if in their opinion it is necessary, before the proper legislative committee, in support of the proposed changes.

On motion of Mr. Howland, it was voted to postpone the consideration of the motion until the next meeting.

Mr. Henry Manley was appointed a committee to make the necessary arrangements for the annual dinner of the Society.

On motion of Mr. Adams, the thanks of the Society were voted as follows: To Messrs. R. L. Fosburg & Sons, Contractors, and their Superintendents; and to the United Shoe Machinery Company and its Supervising Architect, for courtesies shown the members of the Society on the occasion of the visit to the new buildings of the latter company, at Beverly, Mass., on January 14th. Also, to Mr. Walter B. Snow, Superintendent of the B. F. Sturtevant Company, for courtesies shown on the occasion of the visit to the works of that company on the 27th inst.; also to Mr. B. F. Simmons, Electrical Engineer, N. Y., N. H. & H. R. R., for courtesies shown on the occasion of the visit to the new power house of the railroad company at Hyde Park, Mass.

Mr. George A. Kimball gave a verv interesting talk, illustrated by lantern views, entitled "Notes on Passenger Traffic in Some Foreign Cities." A discussion followed Mr. Kimball's entertaining and instructive talk, in which a number of members took part. Gen. William A. Bancroft, President of the Boston Elevated Railway Company, also briefly addressed the meeting, contrasting the elevated roads in Boston with those in foreign cities.

Adjourned. S. E. Tinkham, *Secretary.*

Engineers' Club of Minneapolis.

172d Meeting, Minneapolis, Minn., January 18, 1904.—At the invitation of the Commercial Club, the meeting was held in their Rooms, 9th floor, Andrus Building.

During the first part of the evening the Club listened to an address by Mr. Warren H. Manning, of Boston, on "Should Minneapolis Acquire More Park Lands, or Improve What It Has, and How? Mr. Manning believed in developing what land Minneapolis already has.

The annual meeting of the Club followed. All of those whose names were proposed at the 169th meeting were elected to membership. The following were proposed for membership: Joseph Lane, W. H. Kavenaugh, E. S. Oliver, R. S. King, A. F. Norcross, M. G. Hooper, H. W. Dixon, A. S. Cutler, Trithiof Magnusson. E. B. Newcombe, Jas. S. Boustead, Austin G. Johnson and Louis Clousing.

The Secretary's report was then given as follows:

Annual Report of the Secretary.

The Secretary submits the following report for the past year, 1903:

Nine meetings were held, as follows:

163d Meeting, January 26th. This was the annual meeting, at which reports of the officers of the previous year were made, and new officers elected. A paper was delivered by Mr. E. P. Burch regarding the old power house at St. Anthony Falls, this paper being illustrated by a number of lantern slides. Prof. W. R. Hoag also showed fifty views of "Good and Bad Roads." Mr. F. E. Rice showed twenty-five views of the new Milwaukee bridge during construction.

164th Meeting, February 16th. This meeting consisted of a dinner given at the Commercial Club Rooms. Addresses were made by Hon. J. C. Haynes, Geo. W. Sublette, Prof. Fred S. Jones, Andrew Rinker, Prof. Geo. D. Shepardson, Geo. W. Cooley and others. Mr. Wm. W. Redfield acted as toastmaster.

165th Meeting, March 16th. This meeting was held in the County Commissioners' Room, and was devoted to papers by Mr. C. A. P. Turner, on "County Bridges," and Prof. W. R. Hoag, on "The Work of the State Drainage Commission." The latter paper was fully illustrated by lantern slides.

166th Meeting, April 20th. Held in the Room of the County Commissioners. A paper was read by Wm. W. Redfield, on the "Panama Canal." Mr. L. S. Gillette recited some of his experiences on his recent trip through the West Indies.

167th Meeting, May 22d. That date being the twentieth anniversary of the organization of the Club, a special meeting was held at the hall, 15 South Seventh Street. Entertainment was provided by Hilyard's colored quartette, St. Paul. Mr. W. H. Eustis delivered a very entertaining address on the "Hawaiian Islands." Refreshments were served.

168th Meeting, October 7th. A visit was made by the Club to the new Chamber of Commerce building; a thorough examination of the power and heating plant was made. Refreshments were served.

169th Meeting, November 16th. Held in the County Commissioners' Room. The meeting was addressed by Mr. Francis M. Henry, on "Changing the Course of Bassett's Creek." Discussions followed by Messrs. Ilstrup, Sublette and others.

170th Meeting, December 5th. The Club visited the plant of the Minnesota Sugar Company, at St. Louis Park.

171st Meeting, December 26th. The Club made a visit of inspection of the mechanical equipment at the Glass Block. Mr. F. M. Overholt explained some of the new and interesting machinery which has been installed there. Light refreshments were served.

The attendance at all of these meetings has been comparatively large.

Only one paper given before the Association this year has been published in the JOURNAL. This is to be regretted, as it is desirable that the Club have as good representation as possible in the JOURNAL.

The meetings of the year have been devoted more to visits and entertainments than literary features.

The Club mourns the loss through death, of one of its charter members, Mr. W. D. Van Duzee, for several years honorary member.

The Club has grown considerably in numbers. At the beginning of the year we had sixty-two active members. During the year forty were elected

to membership. One member has resigned, two have been dropped on account of their having left the city and their whereabouts not being known. Our present membership is 109, or a gain of 75 per cent. for the year.

Respectfully submitted,

J. B. GILMAN, *Secretary.*

The Treasurer's report was as follows:

ANNUAL REPORT OF THE TREASURER, 1903.

MR. H. B. AVERY, President, Engineers' Club of Minneapolis, City.

DEAR SIR:—I beg to submit the following statement of the receipts and expenditures of the Club for the past year:

Balance in cash from 1902	$97.85
Dues of seventy-nine members, 1903	237.00
Dues of nine members, 1904	27.00
Total receipts to date	$361.85
Typewriting and stenographic work	$5.80
Reception Committee badges	1.80
Music, entertainment, etc.	52.25
Stationery	24.25
Printing	42.75
JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES	187.10
Photographs	3.00
Lantern slides illustrating papers	7.50
Work on bookcases and drayage on same	4.80
Hall rent	7.00
Total expenditures to date	$336.25

I would state that all bills, as far as I know, are paid, the only possible exception being the notices for this meeting. Also, $30.20 of this year's expenditures represent the last quarter's dues for the JOURNAL for the year 1902, which I have paid this year.

At the present time we have a cash balance of $25.60.

Respectfully submitted,

B. H. DURHAM, *Treasurer.*

The Librarian and Chairman of Standing Committees reported briefly. J. M. Tate, Chairman of the committee appointed to prepare an exhibit for the Louisiana Purchase Exposition, made a report, showing that very favorable progress had been made.

The election of officers for the ensuing year was then held, which resulted as follows:

President—H. B. Avery.

Vice-President—E. P. Burch.

Secretary—J. B. Gilman.

Treasurer—B. H. Durham.

Librarian—W. W. Redfield.

Representative to the Association of Engineering Societies—Prof. W. R. Hoag.

Finance Committee—C. F. Pillsbury and J. M. Tate.

Upon motion by Mr. Redfield, a vote of commendation was given to the Secretary and Treasurer for their careful work during the past year. The meeting then adjourned.

J. B. GILMAN, *Secretary.*

Montana Society of Engineers.

HELENA, MONT., JANUARY 8 AND 9, 1904.—The fourteenth annual meeting of this Society was held on Friday and Saturday. Friday was devoted to a trip to the Electric Power Plant, located at Canyon Ferry, about eighteen miles from Helena. There the engineers were welcomed by Mr. M. H. Gerry, Jr., and his assistants, and every courtesy shown them. After several hours' stay, which was devoted to an examination of the power plant and the enjoyment of a fine lunch, the party returned to Helena. Friday evening the engineers and their friends were the guests of President Wickes at a "smoker."

Saturday morning the members of the Society, in a goodly number, assembled at 10 o'clock, in the Rooms of the Business Men's Association, for the transaction of business. President Geo. T. Wickes in the chair. The minutes of the last meeting were read and approved. Applications for membership in the Society were read by the Secretary from the following: Russell H. Wilson, Frank Marion Kerr, Frank Ashton Jones, Lewis Webster Wicks and Alexander N. Winchell. On motion, the Secretary was instructed to send out ballots for these parties, after the approval of their applications by the Trustees. The Secretary presented the ballots on the application of Geo. M. Craven, and Messrs. Carroll and Sizer were appointed tellers to count the same. They reported the ballots favorable, and President Wickes declared Mr. Craven duly elected a member of the Society. The election of officers being the next order of business, Messrs Carroll and Sizer were appointed to count the ballots submitted, and reported a unanimous vote in favor of the following-named persons for the various named offices of the Society for the ensuing year:

President—Geo. E. Moulthrop, Butte.

First Vice-President—Ernest W. King, Bozeman.

Second Vice-President—Malcolm L. MacDonald, Butte.

Secretary and Librarian—Clinton H. Moore, Butte.

Treasurer, and Member of the Board of Managers of the Association of Engineering Societies—Sam'l Barker, Jr., Butte.

Trustees—Chas. H. Repath, Edward L. Blossom and Charles H. Bowman.

President Wickes announced the election of the above-named persons, and, President Moulthrop not being present, First Vice-President King took the chair. The annual reports of the Secretary and Treasurer were read and referred, and, after various items of business of a minor character, the Society took a recess till 2 o'clock P.M.

The afternoon session was devoted to the reading of the President's annual address, having for its subject "Early Surveying Reminiscences in the West," and the discussion of various subjects belonging to the engineering profession, confined chiefly to the works of Montana engineers during the past year in this State. Many valuable statements were made and much interest elicited. The Secretary was instructed to prepare a suitable report of the annual meeting in addition to the journal minutes. The Society's appreciation of the various courtesies shown its members by the citizens of Helena was expressed by a unanimous vote, and one of the most successful and pleasant annual meetings of the Society then adjourned. A banquet was held Saturday evening, at the Hotel Helena, with the usual results.

CLINTON H. MOORE, *Secretary.*

ASSOCIATION

OF

ENGINEERING SOCIETIES.

VOL. XXXII. **FEBRUARY, 1904.** NO. 2.

PROCEEDINGS.

Technical Society of the Pacific Coast.

ANNUAL MEETING, SAN FRANCISCO, CAL., JANUARY 22, 1904.—Called to order at 8.30 o'clock P.M. by Past-President Manson.

The tellers appointed to open and count the ballots for officers for the ensuing year reported that fifty-eight votes had been cast, and that each one of the candidates had received fifty-eight votes.

The Chairman thereupon announced that the following members had been elected, and that the Secretary inform them by letter of their election to office:

President—Geo. W. Dickie.

Vice-President—Franklin Riffle.

Secretary—Otto von Geldern.

Treasurer—E. T. Schild.

Directors—C. E. Grunsky, L. J. Le Conte, A. D. Connick, Adolf Lietz and Carl Uhlig.

The Secretary's and Treasurer's reports were then read.

These reports were ordered received and placed on the minutes as a part thereof.

The meeting thereupon adjourned.

OTTO VON GELDERN, *Secretary.*

DIRECTORS' MEETING, SAN FRANCISCO, CAL., FEBRUARY 1, 1904.—Held in the café of the Call Building, after a dinner given by President Dickie. Present, Directors Dickie, Riffle, Schild, Grunsky, Connick, Lietz, Uhlig and von Geldern.

The following committees were appointed:

Executive Committee—Franklin Riffle, Chairman; C. E. Grunsky, Carl Uhlig and H. D. Connick.

Finance Committee—L. J. Le Conte, Adolf Lietz and Carl Uhlig.

Members on the Board of Managers of the Association of Engineering Societies—George W. Dickie and Otto von Geldern.

The Secretary reported that the Board had accepted two lectures at the last meeing:

"Radium and Radio-Activity," by Prof. Edward Booth, for February 5, 1904.

"Herbert Spencer: His Synthetic Philosophy," by F. P. Medina, for March 4, 1904.

The Secretary was instructed to issue a circular calling upon certain members for papers for the spring meeting. It was agreed among the Directors to hold it either on the second or third Thursday of May. Beginning on a Thursday evening, the meeting will last through Friday and Saturday, and close with a banquet on Saturday night.

The Board will be called at an early date to go into the details of making the necessary arrangements for the meeting.

The meeting thereupon adjourned, to be called by the President.

Otto von Geldern, *Secretary.*

Regular Meeting, San Francisco, Cal., February 5, 1904.—Called to order at 8.30 o'clock P.M. by President Dickie, who explained that the usual business would be suspended; that the evening had been set aside for a public lecture, to which the friends of the Technical Society were invited. He expressed his satisfaction in being able to greet so large an assembly, and introduced the lecturer, Prof. Edward Booth, of the University of California, who entertained the audience for over an hour on the subject of "Radium and Radio-Activity," dwelling upon all the noteworthy and interesting features of the latest researches. After the lecture he exhibited a number of samples, shadow pictures and apparatus in illustration of his lecture.

The meeting thereupon adjourned.

Otto von Geldern, *Secretary.*

Engineers' Club of St. Louis.

574th Meeting, St. Louis, Mo., February 3, 1904.—Held at the Club Rooms, 709 Pine Street, at 8 P.M.; President Ockerson presiding. There were forty-two members and ten guests present.

The minutes of the 573d meeting were read and approved, and the minutes of the 361st meeting of the Executive Committee were read.

Upon motion of Mr. S. B. Russell, the Secretary of the Club was appointed a member of the World's Fair Committee.

Messrs. H. H. Morrison, P. R. Goodwin and F. H. Vose were elected to membership in the Club.

The President appointed Mr. A. L. Johnson on the Entertainment Committee in place of Mr. S. E. Freeman, who resigned, owing to absence from the city.

Mr. Julius Pitzman presented a paper upon "Protection of the American Bottom Against Overflow, and Regulation of the Mississippi in the Harbor of St. Louis."

After extended discussion by Mr. Robert Moore, Mr. Helm, Mr. Pitzman and others, the meeting adjourned.

R. H. Fernald, *Secretary.*

575th Meeting, St. Louis, Mo., February 17, 1904.—Held at the Club Rooms, 709 Pine Street, Vice-President Moore presiding.

There were present twenty-two members and eight guests.

The minutes of the 574th meeting were read and approved, and the minutes of the 362d meeting of the Executive Committee were read.

The application of Knud Henrick Jacobsen for membership in the Club was read and referred to the Executive Committee.

A letter from Mr. Chas. Warren Hunt, Secretary of the International Engineering Congress, was read, extending an invitation to the Engineers' Club of St. Louis, to participate in the meetings of the Congress, to be held at the Universal Exposition, October 3 to 8, 1904.

Mr. Robert Burgess presented a paper upon "The Inter-Continental Railway." The paper was interestingly illustrated by lantern slides and maps, and brought out discussion by Messrs. Wheeler, Robert Moore, Bryan and Turner.

The thanks of the Club were extended by Mr. Moore to Mr. Burgess for his able and interesting presentation of the subject.

Adjourned.

R. H. Fernald, *Secretary*.

Civil Engineers' Club of Cleveland.

Cleveland, Ohio, February 9, 1904.—The meeting was called to order by Vice-President B. L. Green. Mr. Reginald A. Wright was elected to active membership. Mr. G. T. Nelles, Chairman of the Nominating Committee, reported the following nominations of officers for the ensuing year: President, Alexander E. Brown; Vice-President, Dr. Dayton C. Miller; Secretary, Joe. C. Beardsley; Treasurer, Robert Hoffman; Librarian, Charles O. Palmer. For Directors—Walter M. Allen and Harry S. Nelson.

Two amendments to the Constitution were introduced, as follows:

Section 3, Article IV.

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At the end of said Section 3 add the following words: "Except in case of the resignation of an active member, whose long and efficient service in the Club, in the judgment of the Executive Board, deserves special recognition and acknowledgment. In such case said Board may, at its discretion, ask such member to withdraw his resignation, and if complied with, shall cause his name to be transferred to the retired list of active members, which is hereby authorized. He shall thereafter be exempt from all fees and dues of the Club, but shall be entitled to all the rights and privileges heretofore enjoyed as an active member, except the right to vote and hold office."

Such membership shall not include the Journal of the Association of Engineering Societies, except upon payment of its actual cost to the Club by such member. The Secretary shall serve written notice on such person of his transfer of membership, as per form B B, in the Appendix.

Signed by M. E. Rawson, Joseph Leon Gobeille and Chas. W. Hopkinson.

Section 7, Article VI.

Page 12.

The third sentence to be stricken out and the following inserted in lieu thereof: "The permanent fund shall not be expended for any purpose, except on the unanimous vote of the Executive Board, confirmed by letter-ballot of the Club, in which two-thirds of the legal ballots cast shall be in favor of such expenditure."

Page 13.

The eighth sentence to be stricken out and the following inserted in lieu thereof: "No money shall be transferred from one fund to another, unless so ordered by unanimous vote of the Executive Board, confirmed by letter-ballot of the Club, in which two-thirds of the legal ballots cast shall be in favor of such transfer."

Signed by B. L. Green, Robt. Hoffman and Joe. C. Beardsley.

A resolution was adopted to pass these amendments to letter-ballot.

A resolution was also adopted requesting the Chairman to appoint a committee of three to inquire into the proposed action of the Legislature relative to the prevention of the pollution of lakes and streams as embodied in the bill of Senator M. W. Harvey; this committee to report at the next regular meeting. The Chairman appointed on this committee Major Kingman, Mr. Ritchie and Mr. Hoffman.

The paper of the evening, "Bituminous Coal Mining," was read by Mr. F. C. Green, and was followed by an extended discussion.

JOE. C. BEARDSLEY, *Secretary.*

Association of Engineering Societies.

Vol. XXXII. **MARCH, 1904.** No. 3.

PROCEEDINGS.

Technical Society of the Pacific Coast.

Regular Meeting, San Francisco, Cal., March 4, 1904.—Called to order at 8.30 p.m. by President Dickie, who stated that the meeting was a general one and for the purpose of listening to an address other than technical. He thereupon introduced Mr. F. P. Medina, member of the Technical Society, who delivered an interesting lecture on "The Synthetic Philosophy of Herbert Spencer," a subject of much interest to the ladies and gentlemen present, who expressed their appreciation by an earnest attention.

The President expressed the thanks of the Society for the courtesy of Mr. Medina.

It was announced from the chair that the following names had been added to the membership list by election:

MEMBERS.

1. Lee S. Griswold, Draughtsman, San Francisco, Cal.
2. John W. Carey, Architect, San Francisco, Cal.

ASSOCIATE MEMBER.

1. W. F. Roloff, Mine Worker, Shasta County, California.

The meeting thereupon adjourned.

Otto von Geldern, *Secretary.*

Montana Society of Engineers.

The regular monthly meeting of the Society was held in the Society Room, Tuttle Block, February 13, 1904. The meeting was called to order at 8.30 p.m., there being a quorum present; President Moulthrop in the chair. The minutes of the annual meeting, held at Helena, January 8th and 9th, were read and approved. An application for membership in the Society from Frank S. Mitchell was read, approved and the Secretary instructed to send out the ballots for the same. The Secretary reported the receipts of ballots pertaining to the applications of Alex. N. Winchell, Russell A. Wilson, Francis M. Kerr, Frank A. Jones and Lewis W. Wickes. The President appointed as tellers R. R. Vail and Robert A. McArthur to count the ballots, and they reported the unanimous election of the above-named candidates. A general discussion of various engineering topics occupied the time till the meeting adjourned.

Clinton H. Moore, *Secretary.*

Boston Society of Civil Engineers.

Boston, February 17, 1904.—The regular meeting of the Boston Society of Civil Engineers was held at Chipman Hall, Tremont Temple, at 7.45 o'clock P.M.; Vice-President Frederick Brooks in the chair. One hundred and fifteen members and visitors present.

The record of the last meeting was read and approved.

Messrs. Ralph E. Curtis, William W. Drummond, Harrison P. Eddy, Henry W. Fenno, Chester J. Hogue, Edward H. Kitfield, Edward S. Larned, Walter E. Parker, Fred M. Randlett and Walter C. Whitney were elected members of the Society.

The Secretary read the memoirs of William C. Ogden and of Frank P. Johnson, which had been prepared by committees of the Society.

The Chair announced the death of George A. Ellis, a member of the Society, which occurred on December 27, 1903, and on motion the President was requested to appoint a committee to prepare a memoir. The President has appointed Mr. R. C. P. Coggeshall as that committee.

The Secretary read a communication from the Secretary of the committee in charge of the International Engineering Congress extending an invitation to the members of this Society to participate in the Congress which will be held in St. Louis, October 3 to 8, 1904. The communication was ordered to be placed on file and the Secretary directed to express the appreciation of the Society for the courteous invitation.

In the absence of Mr. Hodgdon, the Secretary renewed the following motion, action on which was postponed at the last meeting:

Voted, That the Society indorse and recommend the changes in the Boston Building Laws proposed by the committee of the Society in its report made at the meeting held December 16, 1903; and that the same committee be instructed to take the necessary action to submit the proposed changes, with the indorsement of the Society, to the Mayor, and to appear in behalf of the Society, if in their opinion it is necessary, before the proper legislative committee in support of the proposed changes.

Professor Johnson moved to amend the report of the committee by striking out the figures "50" in the last line of the fourth paragraph of the portion of the report relating to concrete, and insert the figures "30," so that the sentence shall read: "Concrete shall not be strained in shear more than 30 pounds per square inch." The motion was duly seconded, and on a vote was declared adopted.

Mr. Leonard C. Wason offered several amendments to portions of the report relating to concrete, and after a short discussion, on motion of Mr. Manley, it was voted to refer the proposed amendments to the original committee for consideration and report.

It was also voted, on motion of Mr. Barnes, that when this meeting adjourns it be to next Saturday afternoon at 2 o'clock, in the Society's library.

The literary exercises were then taken up, and Mr. Leonard C. Wason gave an interesting talk on "Concrete-steel as Applied to Structural Work." The talk was fully illustrated by lantern slides.

Adjourned.

S. E. Tinkham, *Secretary.*

Boston, February 20, 1904.—An adjourned meeting of the Boston Society of Civil Engineers was held in the Society's library at 2 o'clock P.M.; Vice-President Frederick Brooks in the chair. Fourteen members present.

Mr. Cheney, for the Committee on Boston Building Laws, submitted a report in relation to amendments proposed by Mr. Wason. The committee suggested certain changes in the original report, so that it shall read as follows:

The Committee on Amendments to Boston Building Laws would recommend the following amendments to the present law:

Section 19. Immediately before table of *"Deflection.—Modulus of Elasticity"* insert the following:

Shearing and bearing stresses on bolts whether wrought iron or steel shall be not higher than allowed by the above table for wrought iron. All connections in skeleton buildings of which the height exceeds twice the least horizontal dimension, all joints in steel trusses and girders, and all connections of such trusses and girders to the sides of steel columns, shall be made by means of rivets.

Section 19. Amend paragraph beginning "Stresses for Steel," so that it will read:

Stresses for steel are those for *"Structural Steel,"* having an ultimate tensile strength of 55,000 to 65,000 pounds per square inch, an elastic limit of not less than one-half the ultimate strength and a minimum elongation in 8 inches of 1,400,000 divided by the ultimate strength, per cent.

Section 19. Amend the figure for the extreme fiber stress in cast iron in tension by increasing from *2500* to *3000*.

Section 19. In headings under both *"Stonework"* and *"Brickwork,"* after the word "Stresses," insert the words *"in compression."*

Section 19. After the portion devoted to brickwork, insert the following:

Concrete.

When the structural use of concrete is proposed, a specification, stating the quality and proportion of materials and the method of mixing thereof, shall be submitted to the Building Commissioner, who may issue a permit at his discretion and under such further conditions as he sees fit to impose.

In first-class Portland cement concrete containing 1 part cement to not exceeding 6 parts properly graded aggregate of stone and sand, except in piers or columns of which the height exceeds 6 times the least dimension, the compressive stress shall not exceed 30 tons per square foot.

In piers and columns of first-class Portland cement concrete, containing 1 part cement to not exceeding 5 parts properly graded aggregate of stone and sand, where the height of pier or column is more than 6 times and does not exceed 12 times its least dimension, the compressive stress shall not exceed 25 tons per square foot.

In steel-concrete beams or slabs subjected to bending stresses, the entire tensile stress shall be carried by the steel, which shall not be strained above the limits allowed for this material. First-class Portland cement concrete in such beams or slabs, composed of 1 part cement to not exceeding 5 parts of properly graded aggregate of stone and sand, may be strained in compression to not exceeding 500 pounds per square inch. In case 1 part of cement to not exceeding 3 parts of properly graded aggregate of stone and sand is used, this stress may be increased to not exceeding 600 pounds per square inch. Concrete shall not be strained in shear more than 30 pounds per square inch.

Section 23. After "iron," where it first occurs, omit the words, *"or steel,"* and insert *"steel or concrete-steel,"* and after "masonry arches" insert *"or concrete-steel slabs."*

Section 27. After "covers," in third line from end, insert *"or with first-class Portland cement concrete containing 1 part of cement to not exceeding 6 parts of properly graded aggregate of stone and sand, the concrete to be filled in and around the pile heads upon the intervening earth."*

Section 30. In third line, after "nineteen," insert *"or Portland cement concrete as provided in Section 27."*

Section 30. Between lines 15 and 16, after "foundations of brick," insert *"or concrete."*

Section 55 to be amended to read as follows: All new or renewed floors shall be so constructed as to carry safely the weight to which the proposed use of the building will subject them, and every permit granted shall state for what purpose the

building is designed to be used; but the least capacity per superficial square foot, exclusive of materials, shall be:

For floors of dwellings and for apartment floors of apartment and public hotels, 50 pounds.

For office floors and for public rooms of apartment and public hotels, 100 pounds.

For floors of retail stores and public buildings, except schoolhouses, 125 pounds.

For floors of schoolhouses, other than floors of assembly rooms, 80 pounds, and for floors of assembly rooms, 125 pounds.

For floors of drill rooms, dance halls and riding schools, 200 pounds.

For floors of warehouses and mercantile buildings, at least 250 pounds.

The loads for floors not included in this classification shall be determined by the Commissioner, subject to appeal, as provided by law.

The full floor load specified in this section shall be included in proportioning all parts of buildings designed for dwellings, hotels, schoolhouses, warehouses, or for heavy mercantile and manufacturing purposes. In other buildings, however, certain reductions may be allowed, as follows: In girders carrying more than 100 square feet of floor, the live load may be reduced by 10 per cent. In columns, piers, walls and other parts carrying two floors, a reduction of 15 per cent. of the total live load may be made; where three floors are carried, the total live load may be reduced by 20 per cent.; four floors, 25 per cent.; five floors, 30 per cent.; six floors, 35 per cent.; seven floors, 40 per cent.; eight floors, 45 per cent.; nine or more floors, 50 per cent.

Your Committee would state that they have had the co-operation of the Committee on Building Law of Boston Society of Architects and the Building Commissioner of the City of Boston in the framing of the proposed amendments, and also their concurrence in the same.

Respectfully submitted,

JOHN E. CHENEY,
JOSEPH R. WORCESTER,
HENRY A. PHILLIPS.

After a lengthy discussion, it was voted to adopt the report in its amended form, 13 yes and 1 no.

It was further voted that the committee be authorized to appear before the Legislature and report the progress which the Society had made in the consideration of the matter of amending the Boston Building Laws.

Adjourned.

S. E. TINKHAM, *Secretary.*

SANITARY SECTION.

BOSTON, MASS., February 3, 1904.—The first regular meeting of the Sanitary Section of the Boston Society of Civil Engineers was held at Hotel Nottingham, Boston, February 3, 1904. One hundred and twenty members and guests present.

The subject for discussion was "The Use of the Septic Tank in Sewage Disposal Works."

Papers were read by Frank A. Barbour, Boston; George E. Bolling, Brockton; H. P. Eddy, Worcester; X. H. Goodnough, Boston; H. W. Clark, Boston, and Prof. L. P. Kinnicutt, Worcester.

Communications were read by the Clerk from R. Winthrop Pratt, Columbus, Ohio, and Andrew J. Gavett, Plainfield, N. J.

The subject was discussed by C-E. A. Winslow, Massachusetts Institute of Technology; F. Herbert Snow, Boston; Dr. Douglas C. Moriarta, Saratoga, N. Y., and George A. Carpenter, Pawtucket, R. I.

WILLIAM S. JOHNSON, *Clerk.*

BOSTON, MASS., March 2, 1904.—The first annual meeting of the Sanitary Section of the Boston Society of Civil Engineers was held at the United

States Hotel, Boston, March 2, 1904. Eighty-eight members and guests present.

Voted that the reading of the records of the last meeting be omitted.

The report of the Executive Committee was read and accepted.

The names of sixteen applicants for admission into the Section were presented. These applications having been favorably acted upon by the Executive Committee of the Section and the Board of Government of the Society, the Secretary was instructed to cast one ballot for each of the candidates, and they were declared elected to membership in the Section.

The following is a list of the men so elected: Henry J. Glendenning, William W. Burnham, F. G. Berry, Douglas C. Moriarta, M.D., Henry E. Mead, Adolph Getman, E. J. Winn, Theodore L. Pike, William H. Patterson, Patrick E. Pettee, Stephen De M. Gage, George E. Bolling, Earle B. Phelps, W. F. Whitman, George A. Smith and Charles W. Conant.

Voted that a committee of five be appointed by the Chair to retire and bring in nominations for officers for the ensuing year. The Chair appointed C. W. Sherman, J. A. Holmes, A. D. Fuller, C. R. Felton and T. Howard Barnes.

The committee brought in the following nominations:

For Chairman—Lewis M. Hastings.

For Vice-Chairman—Harrison P. Eddy.

For Clerk—William S. Johnson.

For Members of the Executive Committee—Freeman C. Coffin, Leonard Metcalf and George A. Carpenter.

By vote of the Section the Clerk cast one ballot for each of the above, and they were declared elected.

On motion of Bertram Brewer, it was voted that a committee of five be appointed by the Chair to consider the subject of "Uniform Statistics of Sewer Maintenance."

The Chairman appointed the following to serve on the committee: Bertram Brewer, Iriving T. Farnham, W. D. Hunter, W. D. Hubbard and H. P. Eddy.

The subject for discussion at the meeting was "The Cleaning and Flushing of Sewers," and it was participated in by J. L. Woodfall, W. D. Hubbard, Charles R. Felton, Dana P. Libbey, Bertram Brewer, W. C. Parmley, E. S. Dorr and F. H. Snow.

William S. Johnson, *Clerk.*

Report of the Executive Committee of the Sanitary Section of the Boston Society of Civil Engineers.

Boston, March 2, 1904.

The amendment of the By-laws of the Boston Society of Civil Engineers, providing for the formation of sections for the consideration of special branches of engineering, was adopted by the Society at a meeting held December 16, 1903. On the same date a petition, signed by fourteen members of the Society, was presented to the Board of Government for the formation, under the revised By-laws, of a section for the consideration of special subjects relating to sanitary engineering, to be known as the "Sanitary Section of the Boston Society of Civil Engineers." On December 21, 1903, the Sanitary Section was established by the Board of Government in accordance with this petition and under the authority of Section 15 of the By-laws.

Business meetings of the Section thus established were held January 1 and 27, 1904, at which meetings By-laws for the government of the Section were considered and adopted subject to the approval of the Board of Government. The By-laws finally adopted by the Section were approved by the Board of Government on January 27th, and are to be printed in a forthcoming number of the JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES.

At the meeting of January 27th officers were elected to serve until the annual meeting, to be held in March.

The first general meeting of the Section was held February 3, 1904, at Hotel Nottingham, the meeting being preceded by a dinner. To this meeting and dinner a general invitation was extended to all those who were interested in the objects of the Section or in the subject discussed. Dinner was served to 74, and 120 were present at the meeting which followed the dinner.

The subject of the meeting was "The Use of the Septic Tank in Connection with Sewage Disposal Works," and papers were presented by Frank A. Barbour, C.E., of Boston; George E. Bolling, Chemist in charge of Sewage Disposal Works at Brockton; Harrison P. Eddy, Superintendent of Sewers, Worcester; R. W. Pratt, Engineer of State Board of Health, of Ohio; Andrew J. Gavett, City Surveyor of Plainfield, N. J.; X. H. Goodnough, Chief Engineer, State Board of Health of Massachusetts; Douglas C. Moriarta, M.D., Chairman of Sewer Commissioners, Saratoga, N. Y.; George A. Carpenter, City Engineer, Pawtucket, R. I.; H. W. Clark, Chemist of the State Board of Health of Massachusetts; Prof. L. P. Kinnicutt, of the Worcester Polytechnic Institute; C-E. A. Winslow, of the Massachusetts Institute of Technology, and F. Herbert Snow, C.E., of Boston. The papers which were presented at this meeting are to be printed in the JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES.

At the first two meetings of the Section the membership consisted of the fourteen signers of the petition to the Board of Government for the establishment of the Section. Previous to the February meeting an opportunity was given to members of the Boston Society of Civil Engineers to make application for enrollment in the Sanitary Section, and such applications have been received from 100 members and one associate of the Society, making a total membership in the Section of 115, or about 22 per cent. of the total membership of the Society.

Applications have been received from sixteen persons, not members of the Boston Society of Civil Engineers, for Section membership. These applications have been favorably acted upon by the Executive Committee of the Section and the Board of Government of the main Society, and will be presented to the Section at the March meeting.

Respectfully submitted for the Executive Committee,

WILLIAM S. JOHNSON, *Clerk.*

TWENTY-SECOND ANNUAL DINNER.

The twenty-second annual dinner of the Boston Society of Civil Engineers was held at the Hotel Brunswick, Boston, Tuesday evening, March 1, 1904, and was attended by 151 members and guests. An informal reception was held at 6 and the dinner was served at 7 o'clock.

At the after-dinner speaking, the President of the Society, Prof. Ira N. Hollis, acted as toastmaster, and in opening called attention to the change

in the Constitution of the Society which permitted the formation of sections. The Sanitary Section had been organized with a large membership, and he hoped others would soon be formed. He described the true function of a local society of engineers as one which would bring together members of the national societies residing in that district, and expressed the hope that the different engineering societies in Boston would co-operate and form one large local society.

The first speaker introduced was the Hon. James F. Jackson, Chairman of the Massachusetts Railroad Commissioners, who spoke of the deep obligation the Commission was under to the civil engineering profession, upon which it has depended very much. He referred to the difference in railroad managements, where on one road attention is given to the convenience and comfort of the traveling public, while on another the employers are indifferent. This is caused mainly by the disadvantage of corporate organization where the officials never reach the men and by the failure to separate the administrative power and the question of expenditure of money. Mr. John Ritchie, President of the Appalachian Mountain Club, expressed the best wishes and compliments of that Club and his appreciation of the organization of the Boston Society of Civil Engineers and the excellent work it is doing. Prof. A. E. Kinnelly of Harvard University, responded for the electrical engineers, and expressed the desire that the branch of the American Institute of Electrical Engineers in Boston should be more closely connected with the different branches of engineering, for thereby they would gain knowledge of what was being done by engineers of all specialties. Mr. L. M. Hastings, Chairman of the newly-formed Sanitary Section, described the work which that Section hoped to accomplish. Mr. Walter C. Parmley, President of the Civil Engineers' Club of Cleveland, brought the fraternal greeting of that Club, and Capt. W. E. McKay, President of the New England Association of Gas Engineers, closed the speaking of the evening.

Among the guests of the Society, in addition to the speakers already mentioned, were: Gen. S. M. Mansfield, late Chief of Engineers, United States Army; Mr. E. C. Brooks, President New England Water Works Association; Capt. Geo. H. Kearney, United States Navy, and Mr. A. W. Parker. Music was furnished by the Apollo Quartette of Boston.

Boston, March 16, 1904.—The annual meeting of the Boston Society of Civil Engineers was held at Chipman Hall, Tremont Temple, at 7.40 o'clock P.M.; President Ira N. Hollis in the chair. Eighty-six members and visitors present.

The records of the last regular meeting and of the adjourned meeting of February 20, 1904, were read and approved.

The following were elected to membership: Edward G. Bradbury, Albert F. Brown, George A. Clark, Harry W. Clark, Luzerne S. Cowles, Fred B. Forbes, Andrew J. Gavett, Wilberforce B. Hammond, Herbert C. Hartwell, Paul Hansen, William H. Jaques, Edwin R. Olin, John J. Phelan, Herbert W. Sheldon, Frederick E. Tupper, Charles U. Umstead, John J. Van Valkenburg, Ralph Whitman, Rufus M. Whittet and Charles-Edward Amory Winslow.

The question of adopting, at a second meeting, the report of the Com-

mittee on Amendments to Boston Building Laws was then taken up. After a short discussion by Messrs. Main, Cheney and Worcester, and a very exhaustive one in opposition by Mr. Howland, the report was adopted for the second time, as required by the Constitution, 36 voting in favor and 3 against.

The President read the annual report of the Board of Government, which was accepted and ordered to be placed on file.

The Treasurer read his annual report, which was accepted and ordered to be placed on file.

The Secretary read his annual report, which was also accepted and ordered to be placed on file.

Mr. Miner, for the Committee on Excursions, read the annual report of that committee, which was accepted and placed on file.

The Librarian read the annual report of the Committee on the Library, which was accepted and placed on file.

Mr. Howe made verbal reports for the Committees on Quarters and on Advertisements.

It was voted to appropriate the sum of $50 for the purchase of standard engineering books for the Library.

It was voted to refer to the Board of Government, with full powers, the appointment of the special committees of the Society and the selection of the members thereof.

It was voted to refer to the Board of Government, with full powers, the question of exchanging club house and library privileges with other engineering societies and the issuing of cards of identification.

It was also voted to refer to the Board of Government the question of entertaining the British Mechanical Engineers who are to visit Boston this summer, and the Board was also authorized to confer with a committee of the mechanical engineers of Boston, in relation to the matter.

On motion of Mr. Miner, the thanks of the Society were voted to Rear-Admiral Mortimer C. Johnson, Commandant, and to Charles W. Parks, Civil Engineer at the Navy Yard, for courtesies extended to the Society on the occasion of the visit to the Charlestown Navy Yard this afternoon.

Messrs. Austin B. Fletcher and W. Lewis Clark, the tellers of election, submitted the result of the letter ballot for officers, and in accordance with their report, the following officers were declared elected:

President—Frederick Brooks.

Vice-President (for two years)—Otis F. Clapp.

Secretary—S. Everett Tinkham.

Treasurer—Edward W. Howe.

Librarian—Frank P. McKibben.

Director (for two years)—Leonard Metcalf.

The President-elect was then presented, and in a few pleasant words thanked the Society for the honor conferred upon him.

President Hollis then addressed the meeting in a very interesting manner, taking for his subject "Some Data on Marine Engines."

Adjourned.

S. E. Tinkham, *Secretary.*

Annual Report of the Board of Government for the Year 1903-04.

Boston, March 16, 1904.

To the Members of the Boston Society of Civil Engineers:

In compliance with the requirements of the Constitution, the Board of Government submits its report for the year ending March 16, 1904.

At the last annual meeting the total membership of the Society was 509, of whom 502 were members, 2 honorary members and 5 associates. During the year we have lost 14 members: 5 by resignation, 4 by forfeiture of membership for non-payment of dues and 5 by death. There have been added to the Society during the year 33 members, of whom 30 are new members, 3 are members reinstated by the Board of Government and 1 has been transferred from temporary membership to permanent membership. Our present membership consists of 2 honorary members, 8 associates and 518 members, a total of 528. Two additional members have been elected, but have not yet completed their membership. Sixteen new members have been elected in the Sanitary Section, of whom 4 have completed their membership at this date. The record of deaths during the year is:

George R. Hardy, died April 2, 1903.

Alphonse Fteley, died June 11, 1903.

William C. Ogden, died October 12, 1903.

Frank P. Johnson, died November 1, 1903.

George A. Ellis, died December 27, 1903.

Ten regular and two special meetings have been held during the year, and the twenty-second annual dinner was given at the Hotel Brunswick, on March 1, 1904. The average attendance at the regular and special meetings was 81; the largest attendance was 130, and the smallest 35. The number at the annual dinner was 151.

At the several meetings the following papers have been read:

March 18, 1903.—Mr. A. W. Parker, "Early and Curious Types of the Cantilever Bridge in New England." (Illustrated.) Discussion.

Address of President George A. Kimball.

April 15, 1903.—Memoir of George R. Hardy.

May 20, 1903.—Dr. Louis Duncan, "The Electrical Transmission of Power."

June 24, 1903.—John R. Freeman, "Problems Connected with the Proposed Charles River Dam." (Illustrated.)

September 16, 1903.—William O. Webber, "Rainfall and Run-off of New England and Atlantic Coast Streams." Discussion. (Illustrated.)

October 21, 1903.—President Ira N. Hollis, "Description of Concrete Stadium for Harvard College."

December 8, 1903.—Prof. L. J. Johnson, "Prominent Features in the Design of the Steel-Concrete Work of the Harvard Stadium." (Illustrated.) Discussion by Professors Norton and Lanza of the Institute of Technology and Professor French of the Worcester Polytechnic Institute.

December 16, 1903.—Memoir of Alphonse Fteley.

January 14, 1904.—George B. Francis, "Timber Crib Foundations." (Illustrated), and "Description of the Construction of a Double-track Third-rail Electric Road Between Scranton and Wilkesbarre." (Illustrated.)

January 29, 1904.—George A. Kimball, "Notes on Passenger Traffic in Some Foreign Cities." (Illustrated.)

February 17, 1904.—Leonard C. Wason, "Concrete-Steel as Applied to Structural Work." (Illustrated.)

On account of the number of special meetings of the Society and the meetings of the Sanitary Section, the only informal meeting held during the year was on April 1, 1903, at which a discussion was held on the best method of making tight joints in pipe sewers, Mr. E. W. Branch speaking particularly on experiments made with asphalt joints.

During the year the Constitution and By-laws of the Society have been amended as follows: (1) In relation to dues. Those now joining the Society pay no dues during the first year, their initiation fee being considered sufficient to entitle them to membership for one year. (2) A salary of $50 has been voted for the services of the Librarian. (3) Section 15 has been changed to provide for Sections of the Society. The charges for those members of the Sections who are not members of the Society are $5 entrance fee and $5 annual dues.

The modification of Section 15 marks a change in the organization of the Society in the direction of recognizing specialization in engineering. This change was foreshadowed by allowing the use of the library to two New England societies, namely, the New England Waterworks Association and the Gas Engineers. It seems to proceed upon the theory that the Boston Society of Civil Engineers should be the general society of this community, and that the societies built up upon specialties should be branches thereof.

One Section was established, to be called the Sanitary Section of the Boston Society of Civil Engineers, by petition of fourteen members of the Society presented to the Board of Government on December 16, 1903. This Section was authorized by the Board of Government on December 21st, and the By-laws finally adopted were approved by the Board of Government on January 27th. Officers have been elected, and the first general meeting of the Section was held on February 3, 1904, at the Hotel Nottingham. The Section now numbers 114 members and 1 associate of the Boston Society of Civil Engineers and 4 members who are not members of the Boston Society of Civil Engineers. Thus the total membership is 119. Two papers have been read at meetings of the Section: (1) "The Use of the Septic Tank in Connection with Sewage Disposal Work." (2) "The Cleaning and Flushing of Sewers."

There has been some discussion among the mechanical engineers of this neighborhood as to the advisability of establishing another section of the Boston Society of Civil Engineers. A committee was appointed to consider the subject and various meetings were held. At a meeting of mechanical engineers on February 25th, it was voted to recommend that the mechanical engineers in New England become members of the Boston Society of Civil Engineers. The committee appointed to consider the subject had been unanimously of the opinion that the mechanical engineers should not organize themselves into a local society separate from civil, electrical and other engineers, the reasons given being as follows: (1) The Society is of long standing as an existing organization, and is in a flourishing condition. (2) It has its own library, immediately available for the use of those joining the Society. (3) It has a well-established and high-grade journal for the publication of papers presented at its meetings. (4) Its membership includes already between 500 and 600 engineers belonging to all branches of the profession. It is hoped that this discussion by the mechanical engineers may result in a large increase of membership in our Society.

A committee of the Society, consisting of three members, was appointed in the late fall to consider the Boston building laws, and to suggest to the Legislature such modifications as seemed advisable. This committee has appeared at several hearings, and its report has been considered by the Society, although it is not yet approved. The discussion of the work of the committee has given rise to some further consideration of the policy for the future. Is it good policy for the Society to make recommendations in regard to legislative enactments, especially where the recommendations involve a large amount of professional experience? Where the subject is one involving the welfare of the community, such as the better construction of buildings, it has seemed to the Board of Government entirely proper for the Society to appear and to assist the State by its advice.

The income of the Society during the year has just met its expenses. Nevertheless, the Board of Government has adopted the recommendation of previous Boards with regard to the purchase of engineering books to be placed in the library. The sum of $50 was voted for this purpose, and it is earnestly recommended that the practice be continued.

A badge of the Society was adopted during the fall, and 125 of the members have purchased them.

During the spring of 1903 the Board of Government voted to allow the New England Association of Gas Engineers a bookcase and library privileges in the Society rooms.

It has been suggested, in accordance with the practice of other engineering societies, that arrangements be made for an exchange of club house and library privileges with the several national and local engineering societies. By means of a card of identification issued to its members, this Society would thus have open to it the rooms of societies in a number of cities. The Board of Government recommends this to the consideration of the Society.

For the Board of Government,
IRA N. HOLLIS, *President.*

ABSTRACT OF THE TREASURER'S AND THE SECRETARY'S REPORTS FOR THE YEAR 1903-04.

CURRENT FUND.

Receipts:		
Dues from new members	$137.00	
Dues for year 1898-99	8.00	
Dues for year 1903-04	3,354.00	
Dues for year 1904-05	31.00	
Sales of JOURNALS and library fines	9.21	
Rent of rooms	933.33	
Advertisements in JOURNAL	448.20	
Interest on deposits	18.56	
Balance on hand March 19, 1903	520.07	
		$5,459.37
Expenditures:		
Rent	$1,685.00	
Association of Engineering Societies	1,037.30	
Printing, postage and stationery	625.85	

Salary of Secretary	$400.00	
Furniture	171.40	
Library maintenance	143.46	
Incidentals	137.01	
Commission on advertisements	134.70	
Salary of Custodian	100.00	
Annual dinner	90.50	
Stereopticon	60.00	
Periodicals	53.30	
Books	48.70	
Binding	48.25	
Lighting rooms	42.42	
Reporting meetings	39.00	
Salary of Librarian	16.66	
Sample badges	15.00	
		$4,848.55

Balance on hand March 16, 1904	$610.82
Due from Permanent Fund	169.43
Cash balance March 16, 1904	$441.39

PERMANENT FUND.

Receipts:

Thirty-one entrance fees, Society	$310.00	
Four entrance fees, Sanitary Section	20.00	
Interest on deposits, Savings Banks	242.64	
Subscription to Building Fund	100.00	
Interest on bond	36.00	
Balance on hand March 19, 1903	264.57	
		$973.21

Expenditures:

Dues on shares Merchants' Co-operative Bank	$300.00	
Dues on shares Volunteer Co-operative Bank	300.00	
Dues on shares Workingmen's Co-operative Bank	300.00	
Deposit in Provident Institution for Savings	44.55	
Deposit in Boston Five-cents Savings Bank	41.55	
Deposit in Warren Institution for Savings	39.35	
Deposit in Franklin Savings Bank	38.49	
Deposit in Eliot Five-cents Savings Bank	39.85	
Deposit in Institution for Savings in Roxbury	38.85	
		$1,142.64

Due Current Fund	$169.43

PROPERTY BELONGING TO THE PERMANENT FUND, MARCH 16, 1904.

25 shares Volunteer Co-operative Bank	$3,272.50
25 shares Workingmen's Co-operative Bank	2,932.48
25 shares Merchants' Co-operative Bank	2,327.12
Deposit in Provident Institution for Savings	1,306.83
Deposit in Boston Five-cents Savings Bank	1,218.83

Deposit in Eliot Five-cents Savings Bank	$1,168.92
Deposit in Warren Institution for Savings	1,153.95
Deposit in Institution for Savings in Roxbury	1,140.27
Deposit in Franklin Savings Bank	1,129.07
One Republican Valley Railroad bond (par value)	600.00
	$16,249.97
Less amount due Current Fund	169.43
	$16,080.54
Amount as per last annual report	14,998.74
Increase during the year	$1,081.80

TOTAL PROPERTY OF THE SOCIETY IN THE POSSESSION OF THE TREASURER.

Permanent Fund	$16,249.97
Current Fund	441.39
	$16,691.36
Amount as per last annual report	15,518.81
Total increase during the year	$1,172.55

Report of Committee on Excursions.

Boston, March 16, 1904.

To the Members of the Boston Society of Civil Engineers:

The Committee on Excursions herewith presents its annual report for the year 1903-04:

Twelve excursions have been made during the year, as follows:

May 20, 1903.—To the State Street Section of the East Boston Tunnel. Attendance, 35.

June 17, 1903.—An all-day excursion to Providence, R. I. The State House and the State Normal School were visited, and at Field's Point the Chemical Precipitation Works were inspected, and a Rhode Island shore dinner was provided for the party. On the return trip a stop was made at Fall River, and the grade-crossing work there was inspected. Attendance, 44.

July 25, 1903.—To the pumping station, reservoir and dam of the Lynn Waterworks at Lynn Woods. Attendance, 40.

August 22, 1903.—A harbor excursion to Boston Light and to the Graves Light now building. Attendance, 111.

September 16, 1903.—To the East Boston Tunnel. The party entering the tunnel at Maverick Square and walking through to the Old State House. Attendance, 75.

October 17, 1903.—To the Stadium of Harvard University. A concrete-steel structure at Soldiers' Field, Brighton. A heavy rain shower interfered with this excursion. Attendance, 35.

October 31, 1903.—To the Stadium at Soldiers' Field. After the struc-

ture had been inspected, the Harvard-Carlisle foot-ball game was witnessed from the top of the Stadium. Attendance, 90.

November 7, 1903.—To the concrete-covered reservoir of the Brookline Waterworks at Wabon Hill. Attendance, 19.

January 14, 1904.—To the United Shoe Machinery Company's buildings of concrete construction, at Beverly, Mass. Attendance, 47.

January 27, 1904.—To the new buildings of the B. F. Sturtevant Company at Readville, and to the power house of the N. Y., N. H. and H. R. R. Co. at Hyde Park. Attendance, 28.

February 17, 1904.—To the extension of the Commissioners' Channel of Stony Brook through the Back Bay Fens, Boston. Attendance, 19.

March 16, 1904.—To the Charlestown Navy Yard. Under the guidance of the civil engineer of the yard, the coal pockets, dry dock, machine shop, boat house and cordage works were visited. The cruiser "Des Moines" was visited and the machinery was shown by the officers of the vessel. Attendance, 79.

Total attendance, 622. Average 51.8.

Six numbers of the *Bulletin of Engineering Work* have been published during the year.

The Treasurer has a cash balance of $25.05 and 30 coupon railroad tickets to Beverly. The committee expect that their successors will find these tickets useful.

Respectfully submitted,

HERMAN K. HIGGINS, *Chairman,*
FRANKLIN M. MINER, *Sec'y and Treas.*
EDWARD P. ADAMS,
W. LEWIS CLARK,
GEORGE A. KING,
Committee on Excursions.

REPORT OF THE COMMITTEE ON THE LIBRARY.

BOSTON, March 16, 1904.

To the Members of the Boston Society of Civil Engineers:

The Committee on the Library begs leave to make the following report for 1903-04:

As indicated in the report of last year, it has become necessary to increase the shelf room of the library to take care of the large number of books and pamphlets received. This shelf room has been gained by the addition of cases, in which have been placed all of the reference books, which comprises Section 10. The addition of these cases has necessitated the removal of the long table which formerly held the periodicals. The periodicals have been placed in a case made especially for the purpose. During the coming year if the number of books received in the library is as large as during the past year more shelf room will be needed. This can be obtained either by adding more bookcases or by increasing the size of the quarters.

There has been received since the last annual meeting 309 bound volumes, which is approximately 25 per cent. more than has been received in any year since 1897. Of these bound volumes 16 have been purchased

and the remainder are largely reports which have been presented to the Society. In addition to the above bound volumes received and accessioned, 2000 pamphlets—mostly municipal reports—have been received and filed away. The committee wishes to thank the members who have contributed books or pamphlets, and wishes to call attention to the recent circular asking for various reports.

Fines to the amount of $4.46 have been collected and paid to the Treasurer.

The committee wishes to recommend that the practice of purchasing standard engineering books for the library be continued for the coming year.

Respectfully submitted,

Frank P. McKibben,
Kilburn S. Sweet,
Frederic I. Winslow,
John N. Ferguson,
L. J. Johnson,
Committee on the Library.

Engineers' Club of Minneapolis.

173d Meeting, Minneapolis, Minn., February 27, 1904.—The meeting was called to order by Vice-President Burch. The minutes of the last meeting were read and approved. The following names were proposed for membership:

J. J. Flather, Professor of Mechanical Engineering, University of Minnesota.

D. H. Keesling, machinist, 229 Twentieth Avenue, S.

Mr. Tate, Chairman of the Louisiana Purchase Exposition Exhibit, reported progress, showing that a very creditable exhibit was being made ready.

Mr. W. W. Redfield, of the committee appointed to prepare resolutions upon the death of Mr. Van Duzee, reported that a member of the Club who was well acquainted with the deceased was now at work upon an article descriptive of his life and work, to be published in the Journal.

Mr. Francis Henry, associate member of the American Society of Civil Engineers, delivered a paper on "Rice Culture in Texas and Louisiana." A short discussion followed.

Prof. Frederick H. Bass, of the University of Minnesota, read a paper on "The Relation of the Engineer to the Public Health." Mr. Bass' paper had special reference to the present epidemic of typhoid fever on the East Side. He showed, beyond a doubt, that the cause of the epidemic was due to the opening of the East Side pumping station, which is situated below Nicollet Island, where a number of sewers empty into the river. Discussion followed by Messrs. Fanning, Hoag, Pardee, Dr. Hall and others.

A resolution was introduced by Professor Hoag, as follows: That both the East and West Side lower pumping stations should be closed and kept closed, as an epidemic of typhoid fever had always followed the opening of these stations.

An amendment was offered by Professor Bass and accepted by Professor

Hoag that these stations might be used in case of fire. The resolution in it's modified form was unanimously passed.

The meeting then adjourned.

J. B. Gilman, *Secretary.*

Engineers' Club of St. Louis.

576th Meeting, St. Louis, Mo., March 2, 1904.—The meeting was held at the Club Rooms, 709 Pine Street, Wednesday evening, March 2d. President Ockerson presided. There were present twenty-seven members and three guests.

The minutes of the 575th meeting were read and approved, and the minutes of the 363d meeting of the Executive Committee were read.

The application for membership of Mr. Arthur A. Bonsack was presented.

Mr. K. H. Jacobsen was elected to membership.

Mr. Robert Moore read a portion of a letter outlining the proposed trips of the French engineers and the dates of their visits to the Exposition.

The memoir upon the death of Prof. J. B. Johnson, prepared by Edward Flad, W. H. Bryan and J. M. Chaphe, was read by Mr. Bryan and advised spread on the records of the Club.

Mr. S. B. Russell, Chairman of the World's Fair Committee, made a brief report of progress, and asked for a special meeting of the Club, to consider matters relating to material for the proposed souvenir.

On motion of Mr. Pfeifer, the special meeting was ordered for Friday evening, March 11th, at 8 o'clock.

The paper of the evening, by Dr. A. L. McRae, on "A Study of Lord Kelvin's Suggestion for a Heating Plant," was presented. Dr. McRae brought out the idea of the suggestion as one for the use of waste products—such as exhaust steam, water used for cooling purposes in compressor plants, etc. Lord Kelvin suggested a warming system which should be the reverse of a refrigerating plant, *i. e.,* in Lord Kelvin's system heat would be the direct produce and refrigeration the waste. Owing to the relatively low temperatures of the warming materials a large radiating surface would be required. Such a system is not at present practicable, but may be made so.

After discussion by Messrs. Wall, Humphrey, Robert Moore, Russell and Langsdorf, the meeting adjourned.

R. H. Fernald, *Secretary.*

577th Meeting, St. Louis, Mo., March 11, 1904.—A special meeting was held at the Club Rooms, 709 Pine Street, Friday evening, March 11th.

The regular order of business was set aside and the evening devoted to details connected with the publication of the proposed "World's Fair Souvenir" now being prepared by the Club.

Vice-President Moore presided. Twenty-two members were present. Much interest was taken in the special work of the evening.

R. H. Fernald, *Secretary.*

Association of Engineering Societies.

Vol. XXXII. **APRIL, 1904.** No. 4.

PROCEEDINGS.

Civil Engineers' Club of Cleveland.

Report of Committee on bill of Senator Harvey, relative to lake and stream pollution.

Cleveland, Ohio, March 2, 1904.

To the President and Members of the Civil Engineers' Club of Cleveland.

Gentlemen:—At the last meeting of this Club a resolution was adopted directing the appointment of a committee to investigate the action proposed by Senator M. W. Harvey, of this district, relative to the prevention of the pollution of the waters of Lake Erie. The undersigned, members of this committee duly appointed, met in this city, pursuant to the call of the chairman of the committee, on Saturday, February 27, 1904, and gave to the subject such consideration as was practicable, and now have the honor to submit the following report:

"The object of the Bill in question, as therein stated, is to provide for the appointment of 'a commission to investigate the pollution of the waters of Lake Erie and of the rivers and streams of Ohio from which the water supplies of cities and villages is obtained.' To effect this result it is proposed to authorize by law the Governor of the State to appoint 'a commission of three members who are citizens of Ohio, to confer with the Board of Health and the federal authorities, and to investigate and report at the earliest possible date, not later than November 15, 1905, a remedy or remedies which, in their judgment, will decrease, abate or prevent such pollution.'

"It is the opinion of your committee that the information thus sought to be obtained would be of great value and utility to the State of Ohio; and further that the means proposed in the Bill under favorable conditions are adequate to procure the information sought. A commission of three members is large enough for the purpose, but the success or failure of their investigations will depend very largely upon the individual fitness of the members for the work confided to them. They should each be a specialist in some particular department of the subject under investigation, and should be specially educated and trained for work of this character. It is too much to expect that an ordinary citizen, who has given no special thought to and has received no special training for this work, would be able or willing to prepare himself to carry out such an investigation.

"It would seem proper that the commission should contain one civil engineer of experience and mature judgment, who has given special study and investigation to questions of rainfall, surface drainage and the flow of water in rivers and streams. Another member should be a sanitary engineer of wide experience, who has knowledge of the practical methods of town and city drainage and the various ways of disposing of sewage. The third member might well be a lawyer acquainted with the legislation that has been had in other States, and able to determine its value or suitability for the State of Ohio, and to express the result of the finding of the Board in a form to be incorporated in the laws of the State. The Board ought, therefore, to be composed of professional men, men who gain their livelihood by the very kind of work which the State invites them to perform.

"Section 2 of the Bill provides that this commission shall serve without compensation. In other words, it asks these members to tax themselves a number of days' labor for the welfare of the State. This form of taxation is not equitable and is not likely to lead to the best results. The works of unpaid commission are generally worth about what they cost, and the State would do well to adopt the method followed by private individuals or corporations and to offer to pay the market rate for whatever commodity or service it desires. It is suggested, therefore, in criticism of the proposed Bill, that this unpaid commission is a mistake. The compensation need not be very large and ought not to be large enough to induce any one to intrigue for an appointment to serve upon the commission; but there should be a provision, not only for the actual expenses of the commissioners, but also for a moderate per diem compensation for the actual time they may give to the work. This compensation might be $10 or $15 a day, and if it were thought best, the total amount which any commissioner could receive might be limited in the act to $200 or $300. The amount of money appropriated by the act should be increased accordingly. In the selection of men for appointment, it would be an advantage to obtain them from places not too remote, in order that frequent meetings might be had for the purpose of discussion at a small cost for traveling expenses and a minimum loss of time for the members.

"The State of Ohio is bounded on the north by Lake Erie and on the south by the Ohio River. The rivers of the State are, therefore, short and small. The density of the population and the numerous large towns which are being built up threaten a rapid and dangerous pollution of the ordinary sources of water supply for the inhabitants. There can be no question that this is a matter of grave importance. It is too widespread in its cause and effect to be dealt with by individuals or small communities, and in some respects it is even beyond the power of the State; but a beginning should be made, and such information as can be gathered from the experience of older States and countries should be collected and digested, to the end that when action is taken the proved and well-known errors and mistakes may be recognized and avoided."

Respectfully submitted,

(Signed) DAN C. KINGMAN, *Major Engineers, U. S. A.*,

JAMES RITCHIE,

ROBERT HOFFMAN.

Cleveland, March 8, 1904.—The regular meeting of the Civil Engineers' Club of Cleveland was held Tuesday, March 8th, at 8.30 p.m. In the absence of the President and Vice-President the Secretary was elected temporary Chairman.

The following officers were elected for the ensuing year:

For President—Alexander E. Brown.

For Vice-President—Dr. Dayton C. Miller.

For Secretary—Joseph C. Beardsley.

For Treasurer—Robert Hoffman.

For Librarian—Charles O. Palmer.

For Directors—Walter M. Allen and Harry S. Nelson.

The Tellers also reported the adoption of the following amendments to the Constitution:

BALLOT FOR CONSTITUTIONAL AMENDMENTS.

Vote closes March 8th, at 8 o'clock p.m.

Section III, Article 4.

At the end of said Section III, add the following: "Except in case of the resignation of an Active Member whose long and efficient service in the Club, in the judgment of the Executive Board, deserves special recognition and acknowledgment. In such case said Board may, at its discretion, ask such member to withdraw his resignation, and, if this request be complied with, shall cause his name to be transferred to the Retired List of Active Members, which is hereby authorized. He shall thereafter be exempt from all fees and dues of the Club, but shall be entitled to all the rights and privileges heretofore enjoyed as an Active Member, except the right to vote and hold office. Such membership shall not include the Journal of the Association of Engineering Societies, except upon payment of its actual cost to the Club, by such member. The Secretary shall serve written notice on such person of his transfer of membership, as per form B B in the Appendix."

Section VII, Article 6.

The third sentence to be stricken out and the following inserted in lieu thereof: "The Permanent Fund shall not be expended for any purpose except on the unanimous vote of the Executive Board, confirmed by letter-ballot of the Club, in which two-thirds the legal ballots cast shall be in favor of such expenditure."

The eighth sentence to be stricken out and the following inserted in lieu thereof: "No money shall be transferred from one fund to another unless so ordered by unanimous vote of the Executive Board, confirmed by letter-ballot of the Club, in which two-thirds of the legal ballots cast shall be in favor of such transfer."

The reports of the Secretary, Treasurer, Librarian and Program Committee were read and adopted and ordered placed on file. The report of Major Dan C. Kingman, Corps of Engineers, U. S. A., Chairman of a Committee on a bill introduced in the Ohio Legislature by Senator M. W. Harvey, was read. This report (see pages 41 and 42) was adopted by the Club and ordered placed on file. The President's Annual Address, on "The Intercepting Sewer System of Cleveland," was read by the Secretary, and the meeting then adjourned.

Joe C. Beardsley, *Secretary.*

Technical Society of the Pacific Coast.

San Francisco, Cal., February 26, 1904.—A meeting of the Board of Directors was held at the residence of the Secretary, Mr. Otto von Geldern, who had invited the gentlemen of the Board to dinner.

Present: Directors Dickie, Grunsky, Riffle, Connick, Schild, Lietz, Uhlig and von Geldern.

In the discussion of the subject of the coming spring meeting, the following details were agreed upon:

That the meeting begin on the evening of the last Thursday in May, and that it be continued during the following Friday and Saturday.

The program to be outlined as follows:

First evening (Thursday)—Introduction of members and the address of the President.

Second day (Friday)—Morning devoted to visiting points of interest in the vicinity.

Afternoon—Reading two or three of the contributed papers.

Evening—Devoted to the reading and discussion of technical papers.

Third day (Saturday)—Morning, visiting or as may be arranged by the committee.

Afternoon—Reading of technical papers.

Evening—Banquet.

The following contributions have been promised:

1. Prof. C. D. Marx. Subject: "Consideration of Uplift as Affecting the Design of Masonry Dams."
2. John Richards. Subject: "Steam Turbine Motors," illustrated by diagrams.
3. Marsden Manson. Subject: "The Reclamation of a Mountain Swamp."
4. Franklin Riffle. Subject: "Pipe Joints for High Pressures."
5. Prof. F. G. Hesse. Subject: "Jet Pumps—New and Original Developments."
6. C. E. Grunsky. Subject: "The Water Supply of San Francisco."
7. M. C. Couchot. Subject: "Armored Concrete Construction."
8. Prof. C. B. Wing. Subject: "Collection and Discussion of Material in County Highway Bridges."
9. J. J. Welsh. Subject: "Experiments in Driving Piles for a Foundation with a Steam Hammer."
10. C. J. Wheeler. Subject: "Manufacture of Portland Cement."
11. F. P. Medina. Subject: "The Laying of the Commercial Pacific Cable."
12. Loren E. Hunt. Subject: "Timber Tests, Laboratory Methods and Results."
13. H. I. Randall. Subject: "Vertical Railway Curves."

Meeting adjourned, to be called again by the President, and subsequently set for Friday, March 18, 1904.

Adjourned.

Otto von Geldern, *Secretary.*

San Francisco, Cal., March 18, 1904.—A meeting of the Board of Directors was held at the residence of the Treasurer, Mr. E. T. Schild, who had invited the gentlemen of the Board to dine with him.

Present: Directors Dickie, Uhlig, Lietz, Schild and von Geldern. For Director Grunsky, Past President E. J. Molera and for Director Le Conte Prof. C. B. Wing had been appointed to act.

It was ordered that the Secretary distribute return postal cards to all members to gather information as to how many will attend the spring meeting, and whether members will be accompanied by relatives or friends, in order to make provisions for them while in the city.

It was also agreed to send a program of the meeting to all members, including a list of the papers that have been presented to be read.

All papers should be in the hands of the Secretary by the end of April or beginning of May.

The following committees were appointed by the Chair:

Entertainment Committee—Messrs. Uhlig and Schild.

Excursion Committee—Messrs. Molera and von Geldern.

These committees will outline a detailed and definite plan, and may call upon other members to augment the committee, if the work to be done requires additional help.

Meeting adjourned to be called by the President.

Otto von Geldern, *Secretary.*

Montana Society of Engineers.

The regular meeting for March was held in the Society rooms, Tuttle Block, at the usual hour, March 12, 1904. On the arrival of a quorum, Mr. R. R. Vail was chosen Chairman *pro tem.* The minutes of the February meeting were read and approved. Applications for membership in the Society from Herbert McNulta, of Anaconda, Montana, and Carroll R. McCulloch, of Havre, Montana, were read, approved and the Secretary was instructed to send out ballots for these parties. Mr. Frank S. Mitchell was unanimously elected to membership in the Society. A communication from the Brooklyn Engineers' Club requesting the privileges of our Society rooms in case any of the Brooklyn engineers should visit this city was read and and the Secretary was instructed to grant the same and so answer the request. The Secretary read an invitation to the members of the Montana Society of Engineers to attend an International Engineering Congress, to be held at St. Louis, Mo., October 3 to 8, 1904, under the auspices of the American Society of Civil Engineers. The Montana engineers are invited to become members of the Congress, and to take part in its proceedings in person or by written communications.

A long list of subjects for discussion can be obtained for the members of this Society as soon as issued. The membership fee of the Congress is $5, entitling the member to all the publications of the Congress. All members of the American Society of Civil Engineers will be members of the International Congress and entitled to its publications without the above-named fee. There being no further business the meeting adjourned.

Clinton H. Moore, *Secretary.*

Civil Engineers' Society of St. Paul.

St. Paul, Minn., March 14, 1904.—A regular meeting of the Civil Engineers' Society was called to order by President Starkey at 8.15 p.m. Present, twelve members and one visitor. Minutes of the previous meeting read and approved.

A communication from Charles Warren Hunt, Secretary, inclosing prospectus of the International Engineering Congress, was read and ordered acknowledged and filed.

The Secretary was instructed to reply favorably to the Brooklyn Engineers' Club as to exchange of courtesies.

The resignation of Mr. Tracy Lyon was accepted.

Mr. W. A. Truesdell informally presented some interesting facts and conjectures as to the origin of the United States system of land surveys. He has been unable to find, either at Washington or in the Ohio State records, any official reports of the earlier heads of the Government surveys. and very little definite information as to their individual efforts.

Who originated the present system of surveys? His researches have led him to decide that Washington, Harrison, Tiffin and Pease had little to do with the plan. Jefferson possibly may have been concerned in it. The germ of the scheme seems to have originated in 1764 with Thomas Hutchins, afterward the first official surveyor of the public lands (the United States Geographer). His successor, the first Surveyor-General, Rufus Putnam, apparently first suggested the six-mile township of thirty-six lots laid out in ranges.

The present system was established in 1785, and Hutchins surveyed the seven ranges in Eastern Ohio the following year. Putnam, his successor, continued the Ohio survey in 1796, his townships being groups of sections instead of lots, and numbered in the order of to-day. The military bounty lands were laid out in townships five miles square in 1796.

Jefferson deposed Putnam, after six years' service, for accepting careless work, and Jared Mansfield, a careful and expert surveyor, succeeded him. He introduced the correction lines and spherical provisions and perfected the system in its minor details.

A vote of thanks to Mr. Truesdell and immediate adjournment at 10 p.m.

C. L. Annan, *Secretary.*

Boston Society of Civil Engineers.

Boston, April 20, 1904.—A regular meeting of the Boston Society of Civil Engineers was held at Chipman Hall, Tremont Temple, at 7.30 o'clock p.m.; President Frederick Brooks in the chair. One hundred and thirty-two members and visitors present.

The record of the last meeting was read and approved.

The following were elected to membership in the Society as members: Messrs. Edmund M. Blake, Arthur H. Blanchard, Francis H. Boyer, Charles E. Chandler, Waldo S. Coulter, Frederick O. Gage, Winfred D. Hubbard, Robert Jerrett, Lionel S. Marks, Walter S. McKenzie, Ralph H. Stearns,

W. B. Smith Whaley, Wm. G. Wheelock, Jr., and as an associate, Mr. Hervey A. Hanscom.

The Secretary reported, for the Board of Government, the appointment of the following committees:

Committee on Excursions—F. M. Miner, E. P. Adams, E. F. Miller, W. H. Norris and F. E. Winsor.

Committee on Library—F. P. McKibben, K. S. Sweet, F. I. Winslow, J. N. Ferguson and R. S. Hale.

Committee on Advertisements—E. W. Howe, A. S. Glover and F. V. Fuller.

Committee on Quarters—Desmond Fitzgerald, E. W. Howe, C. F. Allen, E. W. Bowditch, G. A. Kimball, W. E. McClintock, I. N. Hollis, T. H. Barnes, F. W. Dean, F. C. Coffin, W. S. Johnson, W. E. McKay, C. W. Sherman, R. S. Weston, C. A. Stone, A. T. Safford and J. W. Ellis.

Members of Board of Managers, Association of Engineering Societies, in addition to the Secretary—J. R. Freeman, Henry Manley, Dexter Brackett and Dwight Porter.

The President then introduced Mr. W. L. R. Emmet, of the General Electric Company, who read a paper, entitled "The Steam Turbine in Modern Engineering." The paper was fully illustrated by lantern slides.

At the conclusion of the reading of the paper, on motion of Professor Hollis, the thanks of the Society were voted to Mr. Emmet for his very interesting paper.

On motion of Mr. McKibben, the following votes were passed:

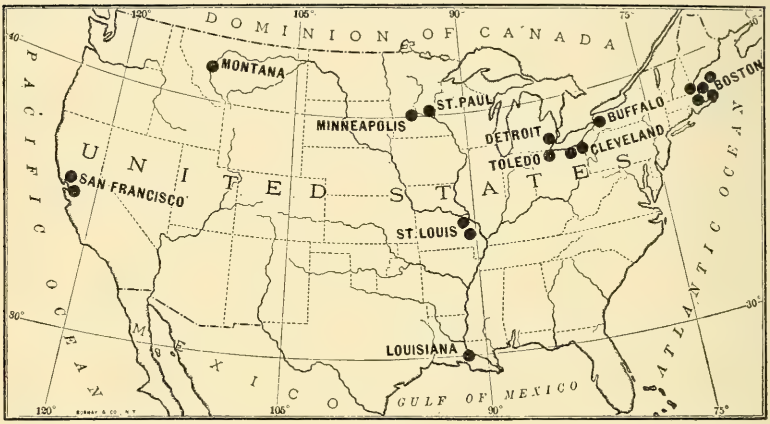
Voted: That the thanks of this Society be transmitted to the President and Directors of the American Telephone and Telegraph Company for the gift of 150 bound volumes of technical periodicals recently received.

Voted: That the privileges of the library and reading room of the Society be extended to the employees of the telephone company.

On motion of Mr. Miner, the thanks of the Society were voted to Mr. C. L. Edgar, President of the Edison Electric Illuminating Company, for courtesies extended to members of the Society on the occasion of the visit to the works of that company this afternoon.

Adjourned.

S. E. Tinkham, *Secretary.*



MAP

Showing the locations of the Societies forming

THE ASSOCIATION OF ENGINEERING SOCIETIES.

(Each dot represents a membership of one hundred, or fraction thereof over fifty.)

Association of Engineering Societies.

Vol. XXXII. **May, 1904.** No. 5.

PROCEEDINGS.

Engineers' Club of St. Louis.

578th Meeting, St. Louis, Mo., March 16, 1904.—Held at the Club Rooms, 709 Pine Street, Wednesday evening; Vice-President Moore presiding. There were present 33 members and 6 guests.

The minutes of the 576th and 577th meetings were read and approved, and the minutes of the 364th meeting of the Executive Committee were read.

Mr. Arthur A. Bensack was elected to membership.

The paper of the evening, by Mr. Hugues Brussel, upon "Armored Concrete Construction," was ably presented, and was pleasingly illustrated by many lantern slides. The lateness of the hour prevented the discussion, which promised to be of great interest.

Adjourned.

R. H. Fernald, *Secretary.*

579th Meeting, St. Louis, Mo., April 6, 1904.—Held at the Club Rooms, 709 Pine Street, Wednesday evening.

With the exception of one or two ladies' nights, the Secretary was unable to find any record of attendance for the past 10 years larger than that of this meeting, there being 45 members and 19 visitors present.

The minutes of the 578th meeting were read and approved, and the minutes of the 365th meeting of the Executive Committee were read.

The Secretary read a letter from the Engineers' Society of Western Pennsylvania offering an exchange of privileges of club rooms, etc.

A letter from Mr. Chas. W. Hunt, Secretary of the International Engineering Congress, to be held in St. Louis, in October, was also read, asking the number of copies desired of the various papers to be presented at the meetings.

An invitation was presented from the Trustees and Faculty of the Case School of Applied Science, Cleveland, Ohio, requesting the Club to be represented by a delegate at the inauguration of Chas. Sumner Howe as President of the institution mentioned, May 11th.

The President was authorized to appoint a delegate.

A very kind invitation was extended to the members of the Club by Mr. Strickler, Superintendent of Construction of the Government Buildings at the Exposition, to visit the Government Building at their pleasure. Mr. Strickler especially requested that the members of the Club make themselves known to him personally that he might extend special courtesies.

The thanks of the Club were expressed to Mr. Strickler for his cordial invitation.

Mr. S. B. Russell, Chairman of the World's Fair Committee, made a brief report, indicating that the souvenir was nearly ready for publication.

The paper of the evening, upon "World's Fair Terminals of the Local Traction Companies and Proposed Methods of Handling Visitors to the Exposition," by Mr. C. A. Moreno, was of unusual and timely interest, and was immediately captured by the *Globe-Democrat* for publication.

A lively discussion followed the reading of the paper, and was participated in by Messrs. Wheeler, Russell, Pfeifer, Perkins, Langsdorf, Smith, Ockerson, Flad, Greensfelder, Van Ornum, Bouton, Phillips and Moreno.

The following paper was announced for the next meeting, April 20th: "Side-Lights on South Africa, Past and Present," by Capt. A. W. Lewis, Manager of the South African Boer War Exhibit Co. at the Exposition.

Adjourned.

R. H. Fernald, *Secretary.*

580th Meeting, St. Louis, Mo., April 20, 1904.—The meeting was held at the Club Rooms, 709 Pine Street, Wednesday evening, April 20, 1904. Vice-President Moore presided.

There were present 26 members and 20 visitors.

The minutes of the 579th meeting were read and approved, and the minutes of the 366th meeting of the Executive Committee were read.

A letter from the Civil Engineers' Club of Boston, offering an exchange of Club Room privileges, was read.

The paper of the evening, entitled "Side Lights on South Africa, Past and Present," was most ably presented by Capt. A. W. Lewis, Manager of the South African Boer War Exhibit Company at the Exposition.

Captain Lewis outlined the South African conditions and the details of the war in an exceedingly interesting and impartial manner.

At the conclusion of the remarks by Captain Lewis, General Cronje consented to address the Club, through his interpreter, Lieutenant Von Peters, and was heartily received and listened to with great interest and pleasure.

The discussion, which consisted largely of inquiries of Captain Lewis and General Cronje regarding the labor and mining conditions of that portion of that country, was participated in by Messrs. Moore, Moreno, Wheeler, Humphrey and Thompson.

A paper entitled "Graphical Methods for Determining the Equations of Experimental Curves," by A. S. Langsdorf, was read by title and ordered forwarded for publication in the Journal. Adjourned.

R. H. Fernald, *Secretary.*

Technical Society of the Pacific Coast.

Regular Meeting, San Francisco, Cal., April 1, 1904.—Called to order at 8.30 o'clock p.m., by President Dickie, who stated that the meeting was held for the purpose of transacting the running business of the Society.

The minutes of the last regular meeting were read and approved.

The following gentlemen were elected to membership: W. Jones Cuthbertson, architect, San Francisco; C. J. Wheeler, chemist, Portland Cement Company, Suisun, Cal.

The following applications for membership were made:

For Members—1. Hugh C. Banks, civil engineer, San Francisco. Refers to Patrick Noble, R. G. Doerfling and C. E. Grunsky.

2. Robert McF. Doble, consulting engineer, San Francisco. Refers to John Richards, Geo. W. Dickie and Otto von Geldern.

For Associate—3. Chas. S. Girvan, Western Fuel Company, San Francisco. Refers to Franklin Riffle, Stetson G. Hindes, Loren E. Hunt and Howard C. Holmes.

In the further discussion of the coming spring meeting and its arrangements, the following details were agreed upon:

That ladies be invited to all social functions, including the banquet.

That all members be notified of this again.

That they indicate on return cards:

1. Whether city members will entertain visiting members, and, if so, how many each one will accommodate?

2. How many will attend the banquet, including the guests of each member?

That a certain number of invitations be issued to prominent men and well-known engineers, such as the Presidents of the universities, the engineering faculties, Lick Observatory director, army and naval engineers, the Mayor of the city and others, who are to be the guests of the Society for the evening.

That the President have power to confer with the trustees of the Academy of Sciences, and perfect an arrangement to obtain the lecture hall of the Academy for the purpose of the Society's meetings in May.

The Secretary was instructed to notify all members of the Technical Society that they are invited to become members of the International Engineering Congress, which is to be held in St. Louis, October 3 to 8, 1904, under the auspices of the American Society of Civil Engineers, and that our members are requested to participate in its proceedings, either in person or by written communications forwarded to the Secretary, on any of the subjects that have been chosen for consideration.

Mr. Loren E. Hunt explained at length the laboratory work of timber testing as done at the University of California, and called attention to the fact that there were at the present time two bills in the hands of a Congressional Committee for the purpose of creating an appropriation for carrying on the very useful work of testing the timbers of the United States. He suggested that the Society call the attention of the California representation in Congress to these bills, and that the support of these measures be urged.

The following resolution was then introduced and unanimously carried:

Resolved, That the Secretary of the Society, on behalf of the members, address a letter to our Senators and Representatives in Congress, calling attention to the so-called "Timber Test" bills, and requesting them to use their best influence and to give their individual support to these measures, which are of vital interest not only to the engineering professions, but also to one of the great industries of the North Pacific Coast.

Resolved, also, That the Secretary be instructed to write an individual and earnest appeal to Senator Perkins to take up this important matter.

No further business appearing, the meeting adjourned.

OTTO VON GELDERN, *Secretary.*

Civil Engineers' Club of Cleveland.

CLEVELAND, OHIO, APRIL 12, 1904.—The regular meeting was called to order at 8.15 P.M. with 36 members present; President Alexander E. Brown in the chair.

The applications of Messrs. F. W. Carroll, E. B. Thomas and W. L. Westcott were reported to the Club with the approval of the Executive Board. The President announced the appointment of the following committee to consider legislation pending in the State Legislature relative to the creation of the office of County Engineer: Messrs. Warner, Gibbs, Handy, Osborn and Barren. The President also announced the appointment of Mr. Ambrose Swasey to represent the Club at the inauguration of Mr. Charles S. Howe as President of the Case School of Applied Science.

Mr. C. H. Wright, Chairman of the Annual Banquet Committee, reported adversely on that proposition: First, because the retiring President had left the city, thus removing the motive for such a banquet; second, that considerable demands would be made upon the Club's treasury during the coming summer for the entertainment of visiting engineers; third, that it seemed desirable to center all the Club's energies on the celebration of the twenty-fifth anniversary, which occurs on March 13, 1905. The report was accepted and the committee discharged.

Mr. Gobeille, Chairman of the House Committee, submitted a report of the operation of that committee from the time of its establishment to the present, together with a resolution to extend the arrangement three years longer. The report was accepted and the resolution adopted. In lieu of a regular paper there was a discussion of the various phases of the "Grade Crossing Problem," led by Mr. W. J. Carter, City Engineer, and Mr. James Ritchie, lately Engineer for the Grade Crossing Commission.

JOE C. BEARDSLEY, *Secretary.*

Civil Engineers' Society of St. Paul.

ST. PAUL, MINN., MAY 9, 1904.—A regular meeting of the Civil Engineers' Society of St. Paul was held at the City Hall at 9 P.M.

President Starkey and seven members present.

Minutes of previous meeting read and approved.

Communications received:

March 12th From Charles Warren Hunt inclosing Circular No. 2 International Engineering Congress. Referred to Secretary.

March 26th—Circular letter from *Railroad Gazette.* It was the unanimous opinion of the meeting that paper 9 x 12 inches would be more convenient than the one of 10½ x 15½ inches for reading and filing; also that it would be preferable to fold "some detail drawings" rather than to reduce the scale of same.

March 26th—From the Engineers' Society of Western Pennsylvania and April 7th from the Boston Society of Civil Engineers, both as to exchange of privileges of library and reading room on presentation of membership card.

The Secretary was instructed to inform both Societies of the readiness of the St. Paul Society to exchange courtesies.

The Society failed to name a delegate to attend the inauguration of the President of the Case School of Applied Science at Cleveland on May 11, 1904.

The President appointed the following examining board: A. O. Powell, A. W. Munster and C. A. Winslow.

A discussion as to increasing the membership of the Society resulted in the appointment of each member present as an independent committee on solicitation with orders to report progress at a special meeting to be called in June.

Adjourned at 10.30 P.M.

C. L. ANNAN, *Secretary.*

Montana Society of Engineers.

THE regular monthly meeting of the Society was held April 9th, in the Society room in the Tuttle Block, at 8 P.M.

There was an unusually large number of members in attendance, as well as ten students from the State School of Mines. At the regular hour the meeting was called to order, Mr. McArthur in the chair. The minutes of the last meeting were read and approved. Messrs. McNulta and McCulloh were unanimously elected to membership in the Society. The Secretary presented the application of James H. McCormick for membership, and, on approval, ballots were ordered circulated. Mr. Charles Metlicka was chosen a delegate to the inauguration of Charles Sumner Howe as President of Case School of Applied Science, Cleveland, Ohio, May 11th.

The Secretary gave notice that the Society must vacate its present quarters, and Messrs. Moulthrop, Harper and Moore were appointed a committee to secure another room.

Mr. Joseph H. Harper gave a very instructive talk on the subject of "Mine Surveying," illustrating his views by practical applications, explaining the various uses of an assortment of engineering instruments at hand, as well as a simple invention of his own. Messrs. Barker, Vail, McDonald, E. H. and others contributed their experiences to Mr. Harper's, and a very interesting meeting closed with adjournment.

CLINTON H. MOORE, *Secretary.*

Association of Engineering Societies.

Vol. XXXII. JUNE, 1904. No. 6.

PROCEEDINGS.

Boston Society of Civil Engineers.

Boston, Mass., May 18, 1904.—A regular meeting of the Boston Society of Civil Engineers was held at Chipman Hall, Tremont Temple, at 7.45 oclock P.M.; President Fred. Brooks in the chair. Sixty-two members and visitors present.

The record of the last meeting was read and approved.

The following were elected to membership in the Society, as members: Messrs. Theodore O. Barnard, Richard Hutchison, Herbert S. Kimball, George W. Mansur, Walter B. Snow and William L. Tobey, and as an associate, Mr. Charles S. Clark.

On motion of Mr. Winsor, the thanks of the Society were voted to Mr. John C. Sanborn, general manager, and to Mr. Edwin J. Beugler, resident engineer, of the Boston Terminal Co., also to the officials of the New York, New Haven & Hartford Railroad Co., who extended courtesies to the Society on the occasion of the excursion to the South Station and to the railroad improvements at South Boston.

The paper of the evening was read by Prof. Charles L. Norton, of the Massachusetts Institute of Technology, entitled "Lessons from the Baltimore Conflagration." The paper was illustrated with lantern slides.

A short discussion followed, in which Prof. F. B. Sanborn, Mr. E. S. Larned, Prof. Norton and others took part.

After passing a vote of thanks to Prof. Norton for the paper of the evening, the Society adjourned.

S. E. Tinkham, *Secretary.*

Boston, Mass., June 15, 1904.—A regular meeting of the Boston Society of Civil Engineers was held at Chipman Hall, Tremont Temple, at 7.30 o'clock P.M.; President Frederick Brooks in the chair. Forty-five members and visitors present.

The record of the last meeting was read and approved.

The following were elected to membership in the Society: As members, Messrs. J. Ansel Brooks, Frank P. Cobb, George D. Emerson, Erwin O. Hathaway, Chester S. Jennings, Frank P. Kennedy, George N. Merrill, William F. Sullivan, and as an associate, Mr. William F. Kearns.

On motion of Mr. Miner, the thanks of the Society were voted to Mr. John F. Fife, Chief Engineer, at Jordan-Marsh Company, and to Mr. W. R.

Fairfield, of Hearst's *Boston American,* for courtesies extended to members of the Society on June 15, 1904.

On motion of the Secretary, the thanks of the Society were voted to Miss Tidd for the gift of a framed portrait of her father, the late Marshal M. Tidd, an honored member of the Society.

The President announced the death of Charles W. Folsom, one of the oldest members of the Society, which occurred on May 19, 1904, and by vote of the Society the President was requested to appoint a committee to prepare a memoir. The following have been appointed as members of that committee: Messrs. Charles W. Kettell, William H. Bradley and Edgar S. Dorr.

Mr. Stephen Child read the paper of the evening, entitled "Landscape Architecture," which was fully illustrated by lantern slides. A general discussion followed in which Messrs. Stearns, Howe, French, Bryant, Hale, Porter and others took part.

Adjourned.

S. E. Tinkham, *Secretary.*

Engineers' Club of St. Louis.

582d Meeting, St. Louis, Mo., May 18, 1904.—The meeting was held at the Club rooms, 709 Pine Street, Wednesday evening, May 18th; President Ockerson presiding.

There were present twenty members and six guests.

The minutes of the 581st meeting were read and approved, and the minutes of the 368th meeting of the Executive Committee were read.

The memorial upon the death of Mr. Geo. W. Fischer, a charter member of the Club, prepared by Messrs. Julius Pitzman, Robert E. McMath and Wm. Wise, was read by the Secretary.

Upon motion of Mr. Bryan, it was ordered spread on the records of the Club and copies ordered sent to Mr. Fischer's children.

The President announced a cordial invitation from Dr. Lewald to the Club to be present at the formal opening of the Engineering Section of the German Exhibit, in the Liberal Arts Building, Friday morning, May 20th, at eleven o'clock.

Mr. Lionel Viterbo was elected to membership in the Club.

Dr. W. J. McGee, Washington, D. C., Chief of the Department of Anthropology at the Exposition, gave a most interesting informal talk on "The Sheetfloods of the Arid Regions and their Relation to Engineering."

The subject was discussed by Messrs. Burgess, Helm, Ockerson, Russell and Dr. McGee.

The President expressed the appreciation and thanks of the Club to Dr. McGee for his kindness in responding to the invitation to address the Club.

Mr. S. B. Russell gave notice of the Good Roads Convention, now in progress in the city, and urged the members of the Club to attend the meetings.

Adjourned.

R. H. Fernald, *Secretary.*

Technical Society of the Pacific Coast.

Directors' Meeting, San Francisco, Cal., April 22, 1904.—Held at the residence of President George W. Dickie, at San Mateo, who had invited the Board of Directors to dinner.

Present, Directors Dickie, Riffle, Schild, Molera, Wing, Connick, Lietz, Uhlig and Von Geldern.

After the dinner the meeting was called to order by the President, and the details of the spring meeting were arranged, as outlined on the program.

Arrangements for the banquet were left in the hands of Messrs. Dickie and Schild.

After a most pleasant evening spent at the San Mateo home of the President, the party returned to San Francisco.

Otto von Geldern, *Secretary.*

Regular Meeting, San Francisco, Cal., May 6, 1904.—Called to order at 8.30 p.m. by President Dickie.

The minutes of the last regular meeting were read and approved.

The following names were added to the list of membership:

Members—Robert McF. Doble, consulting engineer, San Francisco; Hugh C. Banks, civil engineer, San Francisco; C. H. Snyder, civil engineer, San Francisco.

Associate member—Chas. S. Girvan, of the Western Fuel Company, San Francisco.

The President thereupon introduced to the members Mr. Joseph R. Oldham, N.A., who read a most interesting paper on the subject, "The Rise and Fall of the American Merchant Marine and Progress in Ship Design and Construction."

This very important subject was discussed at length by President Dickie, who gave some of his experiences in the line of ship construction and the rehabilitation of ocean commerce in American bottoms.

The author was thanked and a vote of appreciation passed for the courtesy extended to the Society in preparing and reading the paper.

Adjourned.

Otto von Geldern, *Secretary.*

Detroit Engineering Society.

Detroit, Mich., April 29, 1904.—The tenth annual meeting of the Detroit Engineering Society was held in the parlors of the Hotel Ste. Claire. The following officers were elected.

President—T. H. Hinchman, Jr.

First Vice-President—J. D. Sanders.

Second Vice-President—Benjamin Douglas.

Secretary-Treasurer—Clarence W. Hubbell.

After the election of officers the Society adjourned to the hotel dining room, where the tenth annual banquet was served, 66 members being present.

The following is the list of toasts presented at the banquet:

1. "Progress in Railroad Bridge Building," President F. C. McMath.
2. "The University of Michigan," Prof. M. E. Cooley.
3. "The Michigan Agricultural College," Prof. C. L. Weil.
4. Song, Member A. F. Dierkes.
5. "Future Possibilities in Electrical Engineering," Member Alex. Dow.
6. "Recent Progress in Hydraulic Engineering," Prof. Gardner S. Williams.
7. "The Beautiful in Engineering," Member W. S. Russell.
8. "Health and Sanitation," Member A. B. Raymond.
9. Address, President-elect T. H. Hinchman, Jr.

LISTS OF MEMBERS

OF THE SOCIETIES COMPOSING THE

Association of Engineering Societies.

DECEMBER 31, 1903.

	Members.	Page.
Boston Society of Civil Engineers	520	1
Civil Engineers' Club of Cleveland	224	27
Engineers' Club of St. Louis	234	39
Civil Engineers' Society of St. Paul	60	51
Engineers' Club of Minneapolis	93	54
Montana Society of Engineers	160	59
Technical Society of the Pacific Coast	157	66
Detroit Engineering Society	119	74
Engineers' Society of Western New York	81	79
Louisiana Engineering Society	64	83
Total	1712	

Lists of Members of the Associated Societies.

Abbreviations for designating membership:

Mem.	For Member.
Hon. Mem.	For Honorary Member.
Act. Mem.	For Active Member.
Assoc. Mem.	For Associate Member.
Cor. Mem.	For Corresponding Member.
Jun. Mem.	For Junior Member.
Assoc.	For Associate.
Jun.	For Junior.

Boston Society of Civil Engineers.

Adams, Edward P., Mem.,
Landscape Architect and Civil Engineer,
53 State street, Room 1105, Boston, Mass.

Adams, Henry S., Mem.,
Civil Engineer, 71 Ames Building, Boston, Mass.

Addicks, Walter R., Mem.,
Vice-President, Consolidated Gas Co.,
4 Irving Place, New York, N. Y.

Aiken, Charles W., Mem.,
Consulting Engineer, 82 Washington street, New York, N. Y.

Aiken, Roy C., Mem.,
Civil Engineer, cor. Atlantic and Prospect streets, Atlantic, Mass.

Allard, Thomas T., Mem.,
Civil Engineer, Southport, N. C.

Allen, C. Frank, Mem.,
Professor of Railroad Engineering, Mass. Inst. of Technology,
Boston, Mass.

Allen, Charles A., Mem.,
Consulting Engineer, 44 Front street, Worcester, Mass.

Andrews, David H., Mem.,
President. Boston Bridge Works, 47 Winter street, Boston, Mass.

Armstrong, Samuel G., Mem.,
Civil Engineer,
Box 2139, Johannesburg, Transvaal, South Africa.

Aspinwall, Thomas, Mem.,
Aspinwall & Lincoln, Civil Engineers,
120 Tremont street, Room 606, Boston, Mass.

ATWOOD, JOSHUA, 3d, Mem.,
Chief Engineer, Paving Division, Street Department, Boston,
70 City Hall, Boston, Mass.

BADGER, FRANK S., Mem.,
Assistant Engineer, United States Geological Survey,
Wadsworth, Nev.

BAILEY, ERNEST W., Mem.,
City Engineer, City Hall, Somerville, Mass.

BAILEY, FRANK S., Mem.,
Civil Engineer, 177 Washington street, Weymouth, Mass.

BAILEY, WILLIAM M., Mem.,
Engineer, Eastern Expanded Metal Co.,
Paddock Bldg., 101 Tremont street, Boston, Mass.

BAKER, WILLIAM E., Mem.,
W. E. Baker & Co., Engineers, 170 Broadway, New York, N. Y.

BALDWIN, LOAMMI F., Mem.,
Civil Engineer, 31 Milk street, Boston, Mass.

BANCROFT, LEWIS M., Mem.,
Superintendent of Water Works, Reading, Mass.

BARBOUR, FRANK A., Mem.,
Snow & Barbour, Civil and Sanitary Engineers,
1120 Tremont Bldg., Boston, Mass.

BARNES, ROWLAND H., Mem.,
Pierce & Barnes, Civil Engineers, 7 Water street, Boston, Mass.

BARNES, T. HOWARD, Mem.,
Civil and Municipal Engineer, 7 Water street, Boston, Mass.

BARNES, WILLIAM T., Mem.,
Civil Engineer, with Leonard Metcalf, C.E., 14 Beacon street, Boston. Residence, 773 Broadway, South Boston, Mass.

BARNEY, PERCY C., Mem.,
Draughtsman in charge, Dept. of Yards and Docks, U. S. Navy Yard, New York, N. Y.

BARROWS, HAROLD K., Mem.,
Professor of Civil Engineering, University of Vermont,
43 South Prospect street, Burlington, Vt.

BARRUS, GEORGE H., Mem.,
Expert and Consulting Steam Engineer,
12 Pemberton Square, Boston, Mass.

BARTLETT, ARTHUR, Mem.,
Assistant in City Engineer's Office, City Hall, Lowell, Mass.

BARTLETT, CHARLES H., Mem.,
Counsellor at Law and Consulting Engineer,
607 Pemberton Bldg., Boston, Mass.

BARTRAM, GEORGE C., Mem.,
Resident Engineer, Phœnix Bridge Co.,
153 Milk street, Boston, Mass.

BATEMAN, FREDERICK W., Mem.,
Parker & Bateman, Civil Engineers, Clinton, Mass.

BATEMAN, LUTHER H., Mem.,
Assistant Engineer, Harbor and Land Commissioners,
131 State House, Boston, Mass.

BAYLEY, FRANK A., Mem.,
Civil Engineer, 133 Austin street, Cambridgeport, Mass.

BEMENT, ROBERT B. C., Mem.,
Civil Engineer and Contractor, 506 Endicott Bldg., St. Paul, Minn.
BETTON, JAMES M., Mem.,
10 East Sixteenth street, New York, N. Y.
BIDWELL, LAWSON B., Mem.,
District Engineer, Eastern District, N. Y., N. H. and H. R. R., South Station, Boston, Mass.
BIGELOW, JAMES F., Mem.,
City Engineer, 15 Corey Bldg., Marlboro, Mass.
BISSELL, H., Mem.,
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